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INVESTIGATION OF THE NATURE OF SOIL HUMUS SUBSTANCES BY FRACTIONATION

M. M. KONONOVA and N. P. BEL'CHIKOVA, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

It is now an established fact that humus substances are complex polymeric compounds with he basic components ("building blocks") of aromatic and nitrogen-containing organic compounds.

Recent research employing chemical and spectrophotometric methods, X-ray analysis, etc. has revealed that the main groups of humus substances — humic and fulvic acids — are based on similar structural principles. The purely fulvic acids can be regarded as he initial forms of humic acids or their decomposition products. (Cf. the literature and experimental data on these problems in Kukharenko, [7]; Kononova, [3]; Kasatochnik, Kononova, and Zil'berbrand, [1]; Kumada, [14]; Flaig, 9]; Kobo and Tatsukawa, [1, 2]; Kawaguchi and Kyuma, [1]; Scheffer, [17]; Kaurichev and coauthors, [2]; and others).

The variety of humus substances resulting rom the conditions of soil formation shows up n the different degrees of condensability of the aromatic nucleus of the molecules (particles), n the proportion of aromatic and aliphatic structures they contain, and in the different sizes of the particles. Constituting, as they do, a group of polymers, humus substances possess an inherent characteristic of the latter -- heterogeneity. With appropriate methods (fractional precipitation by acids and buffer solutions, ultracentrifuging, electrophoresis, chromatography), any of the humic or fulvic acids can be broken down into several fractions.

Fractionation will undoubtedly help to clariy the nature, structure, and method of formaion of humic substances. The choice of technique and study of individual fractions is largey determined by the particular problems of nterest to the investigator. In an earlier paper (5), we showed data on a comparative study of humic and fulvic acids of various soils utilizing chromatography on columns with starch and aluminum oxide. The substances were broken down into two or three ractions, thus showing their heterogenity. Yet the data characterizing the nature of the ractions (fluorescence, optical properties) ndicates some similarity between the humic and fulvic acids under investigation.

We continued our study of humus substances with the help of paper chromatography, a technique tested by several investigators. However, it was sometimes impossible to obtain a clear-cut division of humus substances into individual fractions by zones (30, 6, 8).

Pavel, Kaloušek, and Smatlak (15) noted a more distinct fractionation of humic acid (Merck) while using unidimensional descending chromatography with pyridine-water as a solvent. Heyashi and Nagai (10), in a comparative study of soil and peat humic acids, used unidimensional ascending paper chromatography, with 1.5% NaOH as the solvent. An examination of the chromatograms in ultraviolet light revealed 3 to 4 zones. It was determined from a comparative study of the substances extracted from the zones that as the humic acids were formed ("ripened") their optical density and content of nonhydrolyzable nitrogen grew steadily.

Equally successful were the attempts of Kroll (13), and Scharpenseel (16) who obtained through paper chromatography a clear division into zones of natural humic acids from various soils and synthetic humus-like substances.

Preparation of Humus Substances and Chromatographic Methods

In our comparative study of humus substances from various soils we selected the method of paper chromatography because the substances from the separate zones were fairly easily eluted with water.

The objects of investigation were humic acid from ordinary chernozem (Kamennaya steppe, Voronezh Oblast') and humic acid and fulvic acids from sod-podzolic soil (Moscow Oblast').

The material was prepared the same way as in the preceding work (5). The humus substances were extracted from soil preliminarily decalcified by repeated processing with a 0.1 n solution of NaOH. The humic acids were precipitated after acidification in the form of a gel in an alkaline extract filtered through a Nutsch No. 4 filter. The gel was dissolved in 0.1 n NaOH to decrease zonality and get rid of impurities. The solution was allowed to stand for 3 to 6 weeks so that the suspended mineral particles could settle. It was then passed through Nutsch No. 4 and Chamberlain filters. The humic acids were again precipitated in the resultant solution by 0.1 n HCl. The gel of humic acids was washed off by decantation in glasses and then dialyzed in cellophane bags until reaction to the Cl ion disappeared. The gel was later air dried.

The acid solution containing the fulvic acids (after precipitating the humic acids from the alkaline extract) was passed through activated carbon where most of the fulvic acids were held. The fulvic acids from the carbon were displaced with small quantities of 0.2 n NaOH, the alkaline solution was neutralized and condensed in a vacuum at 40-45°C until it shrank. It was then dialyzed in cellophane bags and subjected to electrodialysis in chambers with a voltage of 80-100 until reaction to the OH^- was negative. The dialyzed solution of fulvic acids was again condensed in a vacuum and air dried after being spread in a thin layer in Petri dishes. The air-dried preparations of humic and fulvic acids were carefully pulverized and passed through a sieve with holes 0.1 mm in diameter.

The ash content of the humic acids prepared for chromatography amounted to 3%-4%. A check showed that additional precipitation and electrodialysis have a negligible effect on decreasing the percentage of ash (less than 1%). The relatively high percentage of ash in the fulvic acids (Table 1) is apparently due to the presence of complex organo-mineral compounds (possibly iron and aluminum chelates).

While the materials were being prepared by the fore-going methods, the humuc substances were freed from admixtures of non-characteristic organic compounds. We verified the fact that further precipitation, electrodialysis, and extraction with an alcohol-benzene mixture had no noticeable effect on the nature of the chromatograms. The chemical composition of the substances prepared for chromatography is shown in Table 1.

Working solutions of humus substances were prepared for chromatography by dissolving 0.2 g batches in 10 ml of 0.1 n NaOH. The pH value of the prepared solutions of humic and fulvic acids ranged from 8.1-8.3.

We used Leningrad paper brand "M" (slow filtering) from which circles 10-12 cm in diameter were cut out. We placed a drop of the substance being investigated in the center of the paper circle with a micropipette and allowed it to dry in the air. The volume of drop was 0.014 ml. By knowing the carbon content of the solution we were always able to calculate the C of the humus substances applied to any given number of chromatograms.

We cut out a narrow strip or wick from the edge of the circle to the center, bending it perpendicular to the plane of the circle and shortening it to 1.5 cm. Immersed in the solvent, the wick served as a capillary column of the latter. We tested a number of solvents (pyridine, formic acid, NaF, Na-pyrophosphate, a mixture of n-butanol, glacial acetic acid, and water in different proportions, and other things) before selecting a mixture of n-butanol, glacial acetic acid and water in the proportion of 40:12:28. The mixture had a pH of 5.2 and was uniform in specific gravity.

The chromatographic operations were performed at room temperature in a moist chamber constructed as follows. The paper circle with dried drop of substance was placed on an open Petri dish 9 cm diameter into which the solvent had first been poured. This dish was then placed in a larger dish (14 cm diameter) and covered. The operation took 4-5 hours after which the chromatograms were removed from the dishes and allowed to dry (in a draft) until the odor of the solvent disappeared. About 25 chromatograms could be obtained at one time by this method. To obtain enough material from the fractions, we had to prepare 300-500 chromatograms, which was naturally a major technical difficulty. Nevertheless, we refrained from using the method of fractionating humic substances by continuous electrophoresis (fairly extensively employed by investigators, cf. Scheffer, [18]) because the prolonged action of an electric current can change the nature of humus substances.

Type of Chromatograms of Humus Substances in Ordinary and Ultraviolet light; Elution of of Substances from Individual Zones

Two zones were observed in daylight after

Table 1

Chemical composition of initial preparations of humus substances (as a % of absolutely dry, ash-free substance)

Preparations studied	C	H	O	N	C/H	Ash
Humic acid from ordinary chernozem	62,13	2,91	31,38	3,58	21,35	4,19
Humic acid from sod-podzolic soil	57,63	5,23	32,52	4,81	11,02	2,96
Fulvic acids from sod-podzolic soil	46,23	5,05	44,60	4,12	9,15	10,42

Note: Comma represents decimal point.

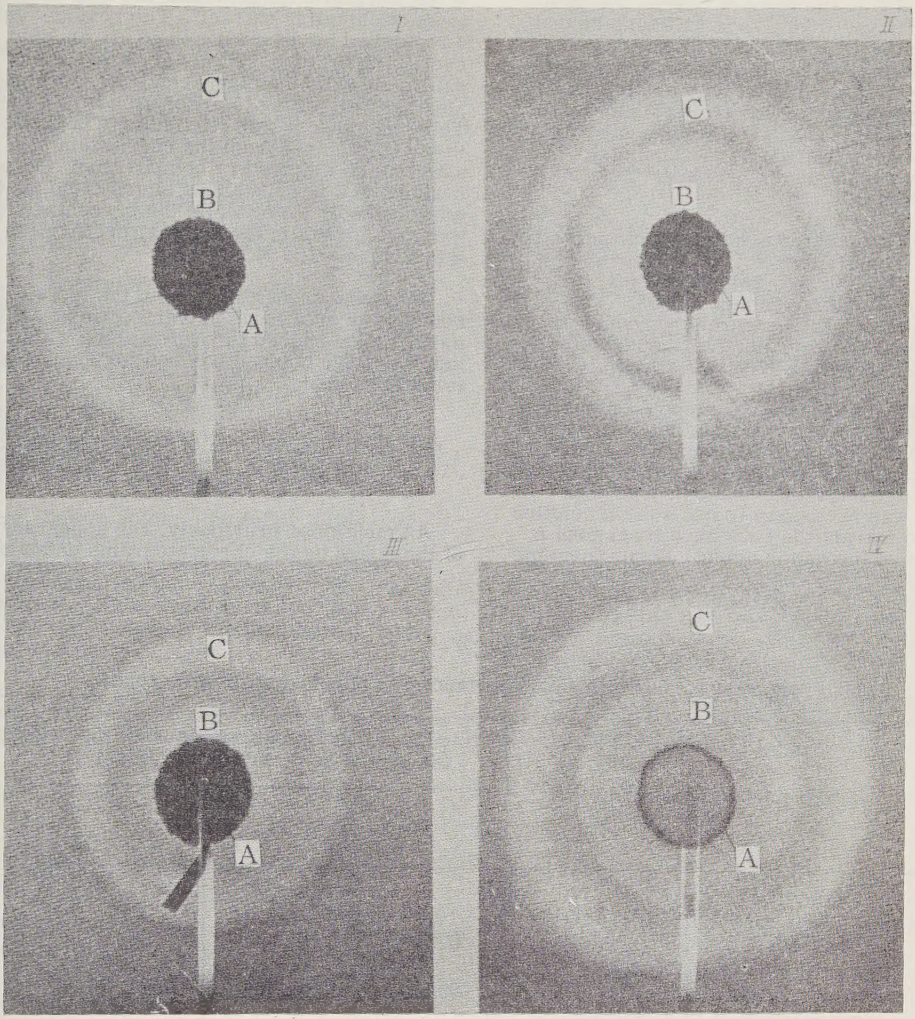

Fig. 1. - Chromatograms of humus substances in ultraviolet light (photographed by V.M. Novgorodtsev)

I - humic acid from ordinary chernozem; II - humic acid from sod-podzolic soil; III - humic acid from strongly podzolic soil; IV - fulvic acids from sod-podzolic soil. On the photograph - I, II, III, IV: A - central zone; B - intermediate; C - peripheral zone.

oration of the solvent on chromatograms e humic acids. The first was in the center e chromatogram in the form of a dark spot e place where the original solution was ied. The second zone was on the periphery e form of a light-brown, faint, narrow ring.

he chromatograms looked quite different in violet light (Fig. 1). Around the dark spot e A) was a fluorescing ring (zone B) that invisible in daylight.

he faint, light-brown ring on the periphery esced in ultraviolet light a yellowish- n color (zone c) of varying brightness and es in the different preparations. A comparison of the chromatograms of the humic acids from chernozem and sod-podzolic soils revealed a somewhat diffuse type of zones in the second object (from the sod-podzolic soil), and more compact type in the first object (from the chernozem).

Two other zones besides the central one could be seen in daylight on the chromatograms of the fulvic acids. The peripheral zone (C) fluoresced a bright greenish-yellow color in ultraviolet light. The general diffuseness of the zones was noteworthy.

To study the individual fractions of the humus substances, we cut out, under ultraviolet light, zones B and C in the form of rings. We then halved the rings, folded each half, and dipped the ends in distilled water. The substances in the half-rings were collected through capillary action of the water into the center, which was then cut out under ultraviolet light. After the excised portions of all the chromatograms of the various preparations were combined, the substances were eluted by steeping them in distilled water.

The resultant water solutions were passed through a Nutsch filter No. 4, condensed in a vacuum at 40-45°C to a volume 5-8 ml, and placed on the bottom of Petri dishes. The liquid was allowed to evaporate at room temperature, and the remaining air-dried substance was removed with a razor blade.

The substances were extracted from central zone A, located where the original solution was applied, in the following manner. The zones were cut out and, in the case of the fulvic acids, the substance was removed with water. It was necessary to use a 0.1 n solution of NaOH to extract the substance from zone A in the case of the humic acids. Here the humic acids were precipitated with the help of HCl from the alkaline extract. The residue (gel) was washed by decantation and air dried at room temperature. However, a portion of th substance remained (apparently of more complex nature), owing to absorption by the paper This phenomenon was particularly noticeable in the humic acid from the chernozem and affected the elementary composition: the percentage of C in substances eluted from zone A was markedly lower while the percentage of H was higher than in the original preparation (cf. Tables 1 and 3).

The substances eluted from the individual zones were air dried, pulverized in an agate mortar, and passed through a sieve with 0.1 mm diameter holes, and used for subsequent investigations.

Nature of Distribution of Humus Substances on Chromatograms; Character of Individual Fractions

As mentioned previously, the appearance of the zones on the chromatograms under ultr

Table 2

Distribution of carbon of humus substances on chromatograms by zones

Humus substances studied	Amount of C in humus substances, mg (computed on 5 chromatograms[a])		
	1	2	3
Humic acid from ordinary chernozem	0,872	0,769	88,2
Humic acid from sod-podzolic soil	0,630	0,390	61,9
Fulvic acids from sod-podzolic soil	0,654	0,308	47,1

---

[a] 1 — applied to the chromatogram; 2 — left in central zone A after distillation; 3 — left as a % of amount applied.

Note: Comma represents decimal point.

Table 3

Content of C and H in fractions of humus substances (as a % of absolutely dry ash-free substance)

Determination	Humic acid				Fulvic acids		
	From ordinary chernozem, zones:		From sod-podzolic soil, zones:		From sod-podzolic soil, zones:		
	A	C	A	C	A	B	C
C	57,45	49,20	56,48	45,38	44,57	43,30	45,35
H	4,26	6,78	4,74	7,50	4,85	5,78	4,45

Note: Comma represents decimal point.

olet light was somewhat unusual. The zones ere more or less diffuse in the case of humic cid and the fulvic acids from the sod-pod- olic soil, while they were more compact in e case of the humic acid from the cherno- em. Evidently, the ratio of different humus ubstances to the solvent we used (a mixture n-butanol, glacial acetic acid, and water) as not identical. This is indicated by the de- erminations of total carbon content, applied the chromatogram, and left in central zone after chromatography (Table 2).

Table 2 shows that more than 50% of the arbon of the fulvic acids shifted into the peri- heral zones, leaving in central zone A only 7.1% of the original amount. The maximum mount of carbon shifted into the peripheral ones in the case of the humic acid from the hernozem, where 88.2% of the carbon re- ained in central zone A. The humic acid om the sod-podzolic soil occupies an inter- ediate position between the two extremes.

Thus, humic acids, like fulvic acids, con- in fractions mobile in an organic solvent ith a weakly acid reaction. In the objects nder investigation the content of these frac- ons varied. They were most abundant in the lvic acids, least so in the humic acid from e chernozem.

The data on C and H content in fractions humus substances (analyses made by the icromethod, Table 3) are interesting.

Before examining Table 3, let us recall that according to the available data on elementary composition of humus substances for the various soils of the USSR the content of C in humic acids ranges from 62%-57%, the content of H from 5%-3%; in fulvic acids the range for C is 41%-49%, for H, 5%-3%. It is evident from Table 3 that the values of C and H for substances eluted from the B zones of the humic acids of both soils are close to the corresponding indices for the fulvic acids. At the same time the percentage of C and H of substances eluted from the central A zones of the humic acids remains characteristic of the latter.

To describe the nature of the individual fractions of humus substances, we determined their optical density, using their water solutions for this purpose. The aforementioned solutions were prepared in identical concentrations — 50 mg of absolutely dry, ash-free substance in 1 liter of solution — to compare the E (extinctions) in the different objects.

We determined the optical density by means of an SF-4 quartz spectrophotometer in wave lengths ranging from 220-350 mμ, the readings made every 5 mμ. Since the thickness of the layer in question was 10 mm, the values of the extinctions E on the upper scale of the reading potentiometer corresponded to the optical density. Spectrophotometric curves (Fig. 2) were plotted from the values of E.

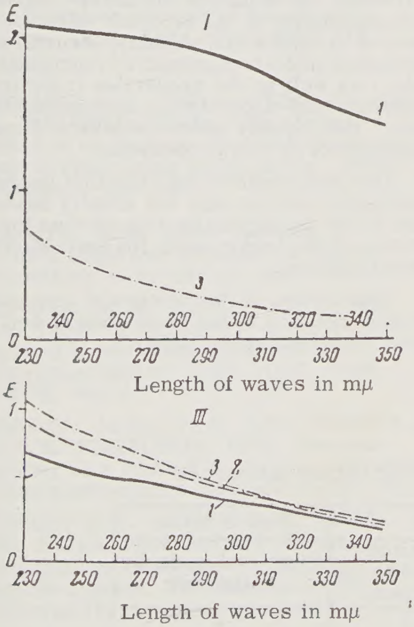

Fig. 2. - Optical density of humus substances

I - humic acid from ordinary chernozem; II - humic acid from sod-podzolic soil; III - fulvic acids from sod-podzolic soil. On the figure: I, II, III: 1 - zone A (central); 2 - zone B (intermediate); 3 - zone B (peripheral).

Figure 2 shows that these curves have a smooth descending character for all the objects, with a maximum of light weakening in the area of the shorter waves, and a minimum in the area of the longer waves. We observed a similar pattern when determining the extinctions of solutions of humus substances in the visible portion of the spectrum (4). However, in absolute values of extinctions there are differences both between substances isolated from different zones of the same object and between substances in the same zones of different objects.

The optical density of substances eluted from zone A (central) was higher in the humic acids than that of substances from zone C, especially in the case of the chernozem. The several fulvic acid fractions differ little among themselves in optical density and their spectrophotometric curves are closer to those for the substances eluted from zone C of the humic acids.

As we showed in an earlier paper (3), when extinction E is determined in solutions of the same concentrations as the substances being tested, it (the extinction) partly reflects the complexity of the molecules or, more precisely, the degree of condensability of the aromatic nucleus. Accordingly, one may draw conclusions from the resultant data (Fig. 2): 1) on greater condensability of the aromatic nucleus in substances remaining in central zone A, particularly in the case of the humic acid of the chernozem; and 2) on weak condensability of the aromatic nucleus in all the fractions of the fulvic acids just as that of the substances found in zone C on the chromatograms of the humic acids.

These conclusions are confirmed by the ratios of extinction E. Several investigators (Welte, [19]; Scheffer, [17]; Kumada, [14]) have shown that the ratios of the extinction values of log K (K is the extinction coefficient) characterize the degree of "ripeness" of the humic acids. With increasing degree of polymerization of the substance this ratio becomes narrower.

We computed the ratios of extinctions at wave lengths of 230/320 mμ and 230/310 mμ and obtained the following results (Table 4).

The clear-cut difference in the ratios of E at 230/320 mμ and 230/310 mμ for substances eluted from zones A and C of the humic acids is noteworthy. The low value of this ratio for substances from zone A suggests that the fractions left in the latter were represented by complex particles (especially in the case of the humic acid from the chernozem).

The ratios of E for substances eluted from the C zones of the humic acids are closer to those in substances from the A and C zones of the fulvic acids. In the latter, unlike the humic acids, the differences in extinction ratios by zones are slight.

The materials described in this communication confirm the heterogeneity of humus substances characteristic of all polymeric compounds and the possibility of breaking down both humic and fulvic acids into several fractions.

The method of circle paper chromatography reveals the presence among humic acids of fractions left at the place of application of the chromatographed solution and of fractions distilled by an organic mixture of weakly acid reaction. The latter fractions, mobile in our solvent, are close to the fulvic acids in elementary composition and optical density.

The content of this ("fulvic acid") fraction in the different humic acids is not identical; it is larger in humic acid from sod-podzolic soil and smaller in humic acid from chernozem. The content of the different fractions in the composition of humus substances determines the nature of the latter (degree of condensability of the aromatic nucleus, proportion of aromatic and aliphatic structures, presence and arrangement of functional groups etc.) as well as the properties (reaction to solvents and electrolytes, acid properties, etc.) that largely affect the role of humus substances in soil processes.

Our data confirm the view that the humic and fulvic acid groups are closely associated; the fulvic acids may be regarded as the initial forms of the humic acids for their decomposition products.

Elucidation of the process of humus formation in relation to the conditions of soil formation requires further study.

Table 4

Ratio of extinctions E for different humus substances

Ratio of wave length, mμ	Humic acid				Fulvic acids	
	From ordinary chernozem, zones:		From sod-podzolic soil, zones:		From sod-podzolic soil, zones:	
	A	C	A	C	A	C
230/320	1,17	3,66	1,68	2,72	2,32	2,85
230/310	1,10	3,20	1,56	2,32	2,12	2,51

Note: Comma represents decimal point.

Conclusions

This paper has described a method of frac-onating humic and fulvic acids by circle aper chromatography together with the results a study of these fractions.

1. The method of circle paper chromato-raphy using a mixture of n-butanol, glacial cetic acid, and water (in the proportion of :12:28) as a solvent made it possible to sep-rate humic and fulvic acids from chernozem d sod-podzolic soils into three fractions.

2. A study of the nature of the substances uted from the zones (reaction to the solvent, and H content, optical density) showed that umic acids contain fractions similar to fulvic cids.

3. These ("fulvic acid") fractions are maxi-ally present in humic acid from sod-podzolic oil, to a lesser extent in humic acid from ernozem.

4. The data confirm the view that humic d fulvic acid groups are closely associated. ulvic acids or their decomposition products ay be regarded as the initial forms of umic acids.

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SOILS AND SOIL-FORMATION PROCESSES IN THE UPPER AND CENTRAL AMUR BOTTOM LAND

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This report is the first experiment in describing the characteristics of bottom land soil formation, classifying and scientifically proving the productive value of bottom land soils in the Priamur'ye. The report is based on material obtained from studying bottom land soils in the vicinity of the village of Kumara in the Amurskaya Oblast', and supplemented by field studies in other parts of the Upper and Central Amur[1] bottom land.

The Kumarskiy bottom land mass is situated within the zone of Far Eastern brown forest soils formed under a canopy of oak-light-conifers (larch and pine) forests. These forests and soils occupy within the USSR the southwest part of the Amuro-Zeyskoye interfluve bordering upon the Amur. The climate of this area lying in the western portion of the monsoon region (1) differs, whenever there is a clearly expressed monsoon character, from the climate of the eastern regions of the Priamur'ye by a sharper continental climate and dryness. From data of the Kumara Meteorological Station (7) the annual mean precipitation is 430 mm, where for the seven warm months (April-October) precipitation is 410 mm, more than half of which (210 mm) occurs in July and August — the months of heavy rainfall. The average monthly temperatures are: -28°C in January, 0.6°C in April, 20.3°C in July, and 0°C in October. The average thickness of the snow cover on the interfluve is not more than 25 cm. Deep freezing of the bottom land soils is the result of severe winters and a small thickness of the snow cover. In the moisture-saturated relatively fine-textured oxbow-shaped bog soils the frozen state lasts for many years, and in the slightly warmed forest soils it begins to thaw only during the second half of the summer.

The climatic peculiarities of the monsoon region, along with the physico-geographic features of the basin determine the specific characteristics of the Amur water level regim From Voyeykov's (4) classification, the Amur River belongs to that type which receives its water supply primarily from rain and which has a sharply-expressed summer high-water state. The Amur hydrograph has several maxima in the course of a year. The high water in the spring is expressed very weakly. A substantial but temporary rise of the water level in the spring may be due to ice jams. The absolute maximum in a year, in most cases, coincides with the end of summer and the beginning of fall. The range of fluctuation in the Amur River level during years of little water is 3-4 m. During the same time, there periodically occur catastrophic floods where the water rises to 10-11 m, even flooding the first terrace above the bottom land (fo example, 1926 and 1958 [11]). A multi-step structure of bottom land, particularly portions of islands, is established by such a water level regime. A series of step reliefs which correspond to the most recurrent flood levels is built above the average annual level of flood-plain waters.

Typical of all bottom lands is the alternatio of ridges (terraces) and depressions between the ridges (oxbow shaped?) which periodically dries up. Especially typical along the river bed is the extensive development of young islands and gravelly- sand bars. The terrace areas are occupied by oxbow-like depressions and channels (Fig. 1).

The Amur bottom land is the formation of a dynamic abundant-water flow which travels 10-12 km per hour in straight channel, sharpl changing flow during the year and from year t year, transporting and depositing large quantities of solid material. According to existing views (11 and 15) the variability of river runoff and alluvium accumulation are the principa causes responsible for river bed straying, change in velocities of individual streams, and growth of bank erosion in the bottom land. These Amur characteristics are responsible for a clearly expressed stratification and micro-stratification of the bottom land deposit particularly of insular bottom land alluvium. This is confirmed by the following description

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[1] Field studies were made jointly with co-workers of the Kheyluntszyvanskaya Expedition of the Academy of Sciences, Chinese Peoples' Republic. The soil, plant, and natural water collections were analytically treated in the laboratories of the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, the Biology and Soil Department of Moscow State University, and GIPROVODKHOZ (State Institute for the Design and Planning of Water Resources and Melioration Development).

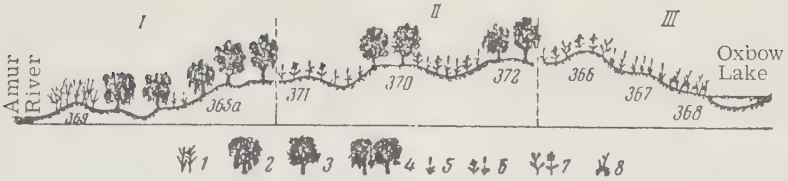

Fig. 1. - A schematic geobotanical profile of typical strips of the Amur bottom land (rayon of the Kumarskiy cliff) and position of the soil profile numbers.

I - Portion of young island; II - Portion of old island; III - Portion of terraced bottom land. 1 - River-bed willow thickets; 2 - grass willow forest; 3 - grass elm forest; 4 - mixed grass broadleaf forest; 5 - reed grass (Calamagrostis) meadow; 6 - mixed grass meadow; 7 - mixed legume-grass meadow; 8 - reed grass-sedge lowland bog.

five profiles of bottom land soils studied, aracterizing the upper alluvium layers of the ost important bottom land elements.

Profile No. 369. A long river bed (low) in- lar bottom land, 2 meters high (above water vel at shore line), thick willow beds.

A_0 0-1 cm. Willow (Salix) litter in initial age of humification.

I 1-11 cm. Moist grayish-light-brown co- sive fine-grained sand, with fine roots. ansition sharp or abrupt.

II 11-28 cm. Moist, gray with rust spots, ratified, with sand and clay interlayers reaks), with buried willow leaves. Maxi- um root accumulation. Transition gradual.

III 28-58 cm. Moist, varicolored sand h clay streaks. Lenses of leaf and twig cumulations.

IV 58-70 cm. Moist, gray, with rust spots, ratified, clay-sandy, with abundance of or- ic matter. The second maximum of tree ots.

V 70-78 cm. Moist, dark gray, with her-colored spots, stratified, silty to sandy dium clay loam, compacted, large amount buried organic matter. Tree roots found.

VI 78-102 cm. Moist, gray-brown, with st spots, stratified, with sand and clay eaks. Buried leaves, willow roots.

VII 102-150 cm. Moist, light-brown, fri- e fine sand with buried leaves.

VIII 150-180 cm. Wet sand with fine pebble d gravel inclusions.

Profile No. 370. A high (central) insular tom land, surface dissected by dried nnels. Profile number laid out on a flat ip in a broad-leafed bottom land forest (elm d cherry (Padus), Chinese apple (Prunus) h a well developed grass cover. A meadow- est bottom land soil.

A_0 0-1 cm. Slightly decomposed friable litter.

A_0A_1 1-9 cm. Moist, cinnamon-brown, fine clay loam, coarsely humic, thickly intertwined with roots.

A_1 I 9-22 cm. Moist, brownish gray coarse clay loam, with lenses of sandy loam, sand, clay, with a faintly expressed stratification, platy-blocky. Very many tree roots.

II 22-36 cm. Moist, gray, medium clay loam, stratified, platy-nutty, compacted, less roots.

III 36-73 cm. Moist, gray-dark blue, with rust spots, gley fine clay loam, with sand, sandy loam, clay streaks, compacted, tree roots rare.

IV 73-98 cm. Moist varicolored sandy medium clay loam, stratified, platy, compacted, isolated fine roots, traces of worms.

V 98-113 cm. Fine clay loam. Moist, dark blue-dark gray, with rust spots. Stratified, platy, compacted, isolated fine roots.

VI 113-150 cm. Moist, cold, varicolored, stratified sandy loam.

VII 150-230 cm. Wet, cold, rusty-gray-dark blue coarse clay loam.

VIII 230-250 cm. Wet, cold, brown, stratified, clayish to sandy.

Profile No. 366. A high (central) continental bottom land, peak of ridge, a mixed legume-grass meadow. A meadow dark colored bottom land soil.

A'_1 0-12 cm. Moist, brownish-black fine clay loam, blocky-granular, compacted, densely pierced by roots. Transition clear.

A'_1 12-28 cm. Fresh grayish-brown fine clay loam, finely blocky, compacted, quite a few roots. Transition by compaction.

A''_1 28-50 cm. Fresh, grayish-brown, sandy medium clay loam, lumpy, very porous. This is the lower limit of the basic root accumulation. Transition sharp, boundary uneven.

C (IV) 50-95 cm. Fresh, pale yellow to

yellow fine-grained sand, cohesive, small humus spots in the upper part of the horizon.

V 95-160 cm. Moist, pale yellow to yellow, fine-grained sand, friable, with broken dark streaks 0.5 mm thick.

Profile No. 367. A high (central) continental bottom land. A dry oxbow lake, covered with a reed grass meadow (20 m from Profile No. 366). A meadow-gley bottom land soil with buried humus horizons.

A'_1 0-17 cm. Moist brownish-black dark-blue, coarse clay, crumb-fine-grained, densely pierced by roots. Upper part less densely penetrated by roots. Very friable.

A'_1 17-54 cm. Moist grayish brown, with dark blue spots, crumbly, sticky, coarse clay, dense root penetration.

A'' buried 54-78 cm. Moist, black, brownish-dark blue coarse clay, non-stable lump. Fine platy, porous, compact, many roots.

B 78-105 cm. Moist, dark blue-brown, with ocherous spots, a fine clay loam, non-stable lump, stratified, with a sprinkling of sand along faces of units, porous, compacted, rare fine roots.

A'' buried 105-150 cm. Moist, dark-blue to black to brown, coarse clay, lumpy, porous, stratified, fine ocherous spots, solitary roots.

B'' 150-170 cm. Moist, brown dark-blue coarse clay, non-stable block, with horizontal cleavability, porous. All horizons have sharply expressed micro-stratification.

Profile No. 368. A high (central) continental bottom land. An oxbow lake. Shore of oxbow-shaped bay, 30 m, from profile No. 367. A sedge-reed grass water-logged meadow (lowland bog) with 25 cm high and 25 cm deep hummocks. A meadow bog bottom land soil.

A_1 0-25 cm. Moist, irregular colored, against a gray brown background, black streaks (slanting and horizontal), ocherous streaks throughout root traces, fine clay loam, dense root penetrations, very sticky.

B'' 25-55 cm. Moist, with alternating dark-blue, brown, rusty and black spots, coarse clay faintly expressed, stratification, porous, many roots.

B_2 55-98 cm. Moist black spots, and streaks, against dark blue background, rust spots, coarse clay, very porous, stratified, small roots.

C 98-145 cm. Water-bearing horizon in frozen state, with streaks and ice crystals, against dark blue background are clear rust spots and black streaks, coarse clay, stratified, porous, solitary fine roots.

Another feature of the Amur alluvial deposits is their general coarse texture. The percentage of clay fraction is not more than 25% (clay materials of the oxbow lakes). At the same time on the fairway channel the pe centage of this fraction in the suspended mat of the Amur is 35%-40%, continually increas on strips having calm currents. This contra tion is explained by the inability to maintain constant sedimentation conditions and, acco ingly, by the microstratification of all samp analyzed (Table 1). As usual, texture becon finer with transition from low bottom land su faces to high. However, there is no sharp differentiation here. Depending upon the co crete conditions in the river bed zone (diluvi deposit strips of islands), an accumulation of medium clay loam is possible while on the high bottom land we may have an accumulati of coarse clay loam (Profile Nos. 369 and 37 respectively).

The distribution curves constructed from data in Table 1, usually have two peaks, whe the predominance of coarse silt and clay fractions is typical of the finer drifts. This proof of the aggregation of the fine fractions after 24 hours standing, the 7 cm layer of Amur water is completely clear.

Amur soil material is formed over a vast area of the Amur basin and includes components, which have emerged within the most va natural zones – from dry steppes and semi-deserts of the Priargun'ye to the mountain taiga and mountain tundra. The basic part o the borne material has already experienced bottom land weathering and soil formation s and is being reworked in the bottom land. T number of fine particles, including alluvium is small; however, they play the most impo role in the development of bottom land soil formation. The specific characteristics and rates of development of bottom land soil and vegetation are closely associated with the te ture of the alluvium.

If soil formation on the pebble sand bars (spits) is in the initial stages, the fine-textu clay material having a high fertility is rapid populated with a higher vegetation. In the suspended matter and recent (fresh) clay m terial, organic matter is continually presen in the form of humus and plant residue. Th alluvial deposits are enriched by organic m and at the submerged stage of their development by the most common algae. The humu content in young alluvial deposits shows a c relationship to the clay fraction percentage. The curve showing this relationship (Fig. 2 is in the form of a straight line passing thro the origin and conforms to the formula: hu = 0.15X clay (in percent). Hydromicas[2] ma up the bulk of the clay minerals in the Amu alluvium. Present are kaolinized hydromic montmorillonite minerals, kaolinite, chlori a small quantity of magnesium silicates (a (palygorskite?). Iron in the recent drifts is essentially in ferrous form; however, crystallized forms of hydroxide (hydrogoethite) have been observed also. The adsorption

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[2] A mineralogical analysis of the clay fraction o fresh alluvium and bottom land soils was made, using the X-ray, thermal and electron microsco methods. This report presents the basic results studies.

Table 1

Particle-size analysis of bottom land soils of the Upper Amur (using Kachinskiy's pipette method), in % (to 0.5%)

Profile No.	Depth, cm	Hygroscopic moist., %	Diameter, mm						
			1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	< 0,001	Solution loss
369	1—11	0,54	None	90,5	4,0	0,5	1,0	3,5	1,0
	15—25	1,93	0,5	62,5	17,5	4,0	4,0	10,0	2,0
	40—50	0,81	0,5	83,5	7,5	0,5	2,5	4,5	1,0
	70—78	2,74	0,5	42,0	25,0	6,0	9,0	15,0	2,5
	120—130	0,39	0,5	94,0	2,5	0,5	2,0		0,5
370	1—9	6,42	4,0	7,5	41,0	9,0	16,0	19,0	3,9
	15—25	2,17	None	45,0	29,0	3,5	7,0	12,5	2,2
	35—45	3,36	"	16,5	38,0	8,0	14,0	20,5	3,0
	50—60	3,29	"	14,0	42,5	8,0	12,5	19,5	3,0
	100—110	3,41	"	10,0	43,0	8,0	14,5	21,5	3,0
	130—140	1,58	"	58,5	23,5	3,0	4,0	8,5	2,0
	180—190	2,18	"	41,0	33,5	5,0	7,0	11,0	2,5
368	0—15	4,01	2,0	13,5	35,0	10,0	15,5	21,0	3,0
	30—40	3,61	None	6,0	37,5	13,5	16,0	24,0	3,0
	70—80	4,04	"	3,5	32,5	15,5	21,5	24,0	3,0
	105—115	3,41	1,0	9,0	40,0	14,5	12,0	21,0	3,0
	135—145	4,06	1,0	18,0	21,0	13,0	20,5	23,6	3,0
367	0—15	4,60	1,5	8,0	34,0	14,0	18,5	21,0	3,5
	30—40	3,44	0,5	13,5	38,5	10,5	15,0	19,0	3,0
	60—70	4,69	1,5	4,0	29,0	15,5	22,5	24,5	3,0
	85—95	3,15	0,5	16,5	41,5	10,0	11,5	17,0	2,5
	120—130	4,26	1,5	5,5	32,0	14,5	19,5	23,5	3,5
	160—170	3,50	1,0	10,5	38,5	10,0	16,0	21,0	3,0
366	0—10	4,16	1,5	15,5	35,0	10,0	16,0	18,5	3,0
	15—25	3,29	None	19,5	35,5	8,5	14,0	19,5	2,5
	35—45	3,44	0,5	21,0	30,5	10,5	14,5	20,5	2,5
	70—80	0,64	None	87,0	6,0	2,5	1,0	3,0	0,5
	120—130	0,36	0,5	94,0	3,5	18			0,5

Note: Comma represents decimal point.

capacity of the clay fraction of recent clay deposits containing 8%-9% humus, is, from O. A. Shelyakina's determinations, 50-60 meq per 100 grams. There is a sharp predominance of calcium in the adsorption complex. Basic contents of microelements (10) are also associated with the clay fraction of alluvial deposits enriched by organic matter. A study of the light fractions of alluvium (Kumara) made by Nikol'skaya (13) showed that in the coarse fraction of minerals having a particle diameter of 0.01 to 0.25 mm there is a predominance of quartz (more than 50%) and potash feldspars; in the heavy fraction biotite and plagioclase are present; in the fine fraction hornblende and epidote, and a large quantity of ilmenite are predominant; biotite, muscovite, zoisite, garnet, magnitite, sphene, (titanite), chlorite, etc. are present.

Alluvium enrichment by plant nutrients, moisture supply from ground nutrition, climatic characteristics of the growing period with high summer temperatures and long warm and moist periods of heavy rainfall, are responsible for the high rates of formation

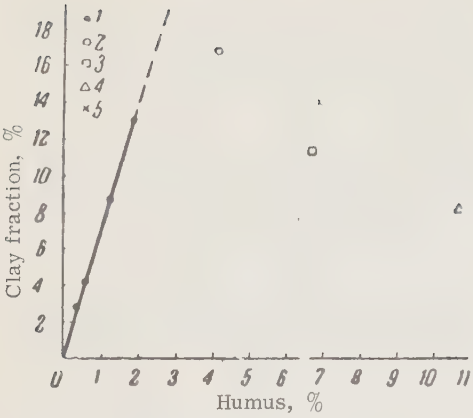


Fig. 2. - Relationship between the percentage of humus and the clay fraction in recent alluvial deposits. (Profile No. 369) and in the upper horizons of bottom land soils.

Profile Nos: 1-369; 2-368; 3-366; 4-370; 5-367.

and differentiation of the bottom land soil and vegetation. As we know, the community of climate, hydrology and geochemical processes is typical of all elements of the bottom land. However, the local differences in soil-formation conditions which are the result of dissimilar geomorphology and elevations of bottom land strips above the water level (level of ground waters!) are capable of ensuring the development of soil formation in various directions. We should particularly stress the complex structure of bottom land vegetation. By considering the independent development of each of the bottom land surfaces, we divide the ecological series of bottom land vegetation into forest, meadow, and bog.

The forest series (from lowest to highest levels) includes the following stages: 1) along the river willow (Salix viminalis); 2) grass-willow forests; 3) grass-elm forests, (with Ulmus propingua); 4) grass-broadleaf forests with elm (Ulmus propingua), apple tree (Malus manshurica), bird cherry (Padus asiatica), Cosenia macrolepis; and 5) broadleaf oak forests. Included in the meadow series are: 1) reed grass meadows (with Calamagrostis Langsdorfii); 2) reed and mixed grass meadows; 3) legume and mixed grass meadows; and 4) mixed grass meadows. The bog series combines: 1) sedge lowland bogs (with Carex appendiculata, C. Schmidtii); and 2) sedge-reed grass waterlogged meadows. These series are related by intertransitions at different stages.

The along the river willows attract into the biological cycle, for the most part, calcium and potassium, a large amount of sulfur, and phosphorus and manganese (Table 2). In the elm forests (variety of grasses, elm leaves), silicon and aluminum play a sharply increasing role when the content of potassium and calcium is high. Reed grass meadows attract into the cycle, for the most part, silicon and much potassium, calcium, and phosphorus. These specific characteristics are peculiar to sedge-reed grass vegetation of bottom land bogs (waterlogged meadows). The legume and mixed grass vegetation of dark colored meadow soils contains an especially large amount of pota sium, calcium, phosphorus, and aluminum.

The amount of grass biomass in the Amur bottom land are very large. In the broadleaf forests grass cuttings are 20-25 cntr per ha when ash content is 10%; the legume and mixed grass meadows yield up to 45 cntr per ha with 4.5% ash content; the grass meadows, up to 50 cntr per ha, the sedge-reed grass water logged meadows, up to 60 cntr per ha when ash content is 5%. These values give us some idea of the scale of the biological cycle in the Amur bottom land.

A comparison of the developed bottom land soils with one another and with the soils of along-river willows enables us to bring out the basic tendencies in the development of bottom land soil.

Organic matter is the most dynamic part of bottom land soils. The humus formation processes are considerably different in the forest, meadow, and bog soils. Thus in the meadow-forest soils (Profile No. 370, Table 3) the highest humus content — 10.7% — is noted in the fine upper layer (1-9 cm), which is associated with the accumulation of partially humified forest litter. In the dark colored meadow soils (Profile Nos. 366 and 226) there is less humus in the upper horizons, but the humus penetrates deeper down through the profile. In the meadow bog soils (Profile No. 368), despite an abundance of biological material, no more than 4.6% humus is accumulated. In the fine-textured interlayers, especially in the buried humus horizons, the percentage of organic matter increases sharply. An analysis of the group and fractional chemical composition of humus has shown that, when there is an equal ratio of humic to fulvic acids in the forest and meadow soils, the humic acids of forest soils are more mobile. (Table 4). There is less nonhydrolyzed residue in forest soils than in meadow soils (27%-31% of total C, Profile Nos. 370, 372), as against 35%-40% in the meadow soils (Profile Nos. 366, 371). At the same time there is an increase in the amount of group I fulvic acids in these soils. The ratio of C:N is narrowest in the humus horizon of dark colored meadow soil (8), increasing to 10 in the meadow bog and meadow forest soil (owing to coarse humus accumulation and differences in humus composition). Thus, the new humus formation in the bottom land soils has a qualitatively and quantitatively different character.

In the development process of the soil and vegetation a certain differentiation in the composition of soil-ground and surface waters of the bottom land takes place. The bottom land waters of the Amur are fresh (60-100 mg per liter), silicate — bicarbonate, of the calcium group (Table 5). Typical is the continuous presence of iron; the waters of the terraced bottom land which experience the effect of runoff from the terraces, contain appreciably more iron than the along the river of bottom

Table 2

Ash composition of bottom land vegetation of the Amur River, % of total ash Samples taken August 8, 1957

Profile No.	Vegetation	Hygroscopic water %	Ash %	Insoluble residue	CO₂	Si	S	P	Al	Fe	P+Al+ +Fe	Ca	Mg	Mn	K	Na	Total
	Vegetation of forest bottom land soils																
369	Willow leaves (Salix viminalis)	7,93	7,22	1,89	12,98	2,00	13,14	6,68	0,44	0,22	7,35	42,09	5,34	2,0	28,06	0,07	100,31
370	Elm leaves (Ulmus propingua)	8,54	14,07	3,17	14,99	39,75	1,06	2,65	1,26	0,25	4,16	41,77	6,06	0,16	7,07	—	99,91
370	Variety of forest grasses (Calamagrastis langsdorfii, Carex redium, Felipendula, etc.)	3,21	10,64	3,30	2,00	40,98	3,47	1,96	0,49	0,16	2,61	14,70	2,61	0,33	35,11	0,13	99,90
370	Roots of forest grass variety (Calamagrastis langsdorfii, Carex redium, Felipendula)	8,91	3,90	11,70	6,85	24,12	1,75	3,95	3,95	3,51	11,40	27,63	7,46	0,48	26,75	0,53	100,12
	Vegetation of meadow bottom land soils Low Levels																
371	Reed grass (Calamagrostis langsdorfii)	6,36	5,28	0,80	1,00	59,00	3,45	4,60	0,77	Trace	5,37	10,34	3,83	0,31	17,24	0,27	98,81
371	Reed grass roots (Calamagrostis langsdorfii)	9,69	6,73	48,14	1,47	39,89	2,73	3,55	11,75	10,93	26,23	14,75	3,82	1,37	10,65	0,55	99,99
	High Levels																
366	Legume and mixed grass vegetation	7,20	4,52	2,08	20,71	10,65	2,41	6,18	2,41	0,24	8,93	29,55	7,90	0,21	39,86	0,24	99,75
366	Roots of legume and mixed grass vegetation	6,62	4,48	31,76	9,51	19,85	3,74	5,24	7,49	4,87	17,61	31,46	7,87	0,30	17,61	1,50	99,94
	Vegetation of meadow bog soils																
367	Reed grass-sedge vegetation (Calamagrostis langsdorfii, Carex appendiculata)	5,79	5,18	1,85	2,62	54,16	2,43	2,78	0,69	0,10	3,47	7,29	2,78	0,69	29,16	0,14	100,12
367	Roots of reed grass-sedge vegetation	6,13	3,59	20,76	5,88	40,50	6,00	4,50	3,50	8,50	16,50	12,50	5,00	1,00	17,00	1,50	100,00

Analyses made by A. G. Amchislavskaya

Note: Comma represents decimal point.

Table 3

Certain physicochemical properties of the bottom land soils of the Upper Amur

Profile No.	Depth, cm	Hygro-scopic water	Humus (after Tyurin)	Nitrogen	C : N	Diameter <0.001 mm, %	Adsorbed cations in meq							Salt pH value
							Ca^{++}	Mg^{++}	H^+	Total	H^+ % total	H^+	Al^{+++}	
		%					After Gedroyts					After Sokolov		
369 [a]	1—11	0,54	0,44	0,049	5,1	3	6,23	Traces	—	6,23	—	0,01	0,05	6,4
	15—25	1,93	1,30	0,063	11,9	10	10,92	1,56	0,10	12,58	0,7	0,07	0,11	5,7
	40—50	0,81	0,59	—	—	5	7,79	Traces	0,08	7,87	1,0	0,01	0,09	5,7
	70—78	2,74	2,01	—	—	15	14,94	1,56	0,06	16,56	0,4	0,05	0,11	5,4
	120—130	0,39	0,38	—	—	Traces	6,23	Traces	—	6,23	—	0,01	0,01	6,6
365	1—20	3,02	3,74	0,292	7,5	18	14,02	3,11	0,08	17,21	0,4	0,03	0,15	5,7
	25—35	0,45	0,37	0,045	4,7	Traces	6,23	Traces	—	6,23	—	0,01	0,03	6,3
	60—70	0,18	0,21	—	—	1	3,12	"	—	3,12	—	0,01	0,03	6,4
	100—110	0,19	—	—	—	Traces	3,12	"	—	3,12	—	0,01	0,03	6,2
370	1—9	6,42	10,76	0,621	10,0	19	31,15	9,34	1,23	41,72	2,9	0,02	0,18	5,0
	10—20	2,17	2,89	0,227	7,4	13	17,13	1,56	0,62	19,31	3,2	None	0,25	4,6
	25—35	3,36	3,26	0,243	7,8	20	20,25	1,59	0,83	22,67	3,7	"	0,20	0,5
	50—60	3,29	2,83	0,171	9,6	20	20,25	3,11	1,31	24,67	5,3	"	0,37	4,3
	100—110	3,41	—	—	—	21	17,13	6,23	0,45	23,81	1,9	0,01	0,13	4,6
	130—140	1,58	—	—	—	9	12,46	4,67	0,03	17,21	0,5	0,01	0,09	4,7
	180—190	2,18	—	—	—	11	14,02	6,23	0,08	20,33	0,4	None	0,03	5,0

Note: Comma represents decimal point.

Table 3 Continued

Profile No.	Depth, cm	Hygroscopic water	Humus (after Tyurin)	Nitrogen	C : N	Diameter <0.001 mm, %	Adsorbed cations in meq								Salt pH value
							Ca^{++}	Mg^{++}	H^{+}	Total	H^{+} % total	H^{+}	Al^{+++}	
		%					After Gedroyts					After Sokolov		
366	0—10	4,16	6,84	0,491	8,1	18	12,46	1,56	—	14,02	—	0,03	0,09	6,0
	15—25	3,29	3,90	0,225	10,9	20	15,57	6,23	0,25	22,05	1,1	0,01	0,13	4,8
	35—45	3,44	3,25	0,213	8,1	20	14,02	6,23	0,45	20,70	2,2	0,01	0,15	4,6
	70—80	0,64	0,46	—	—	3	4,67	1,56	0,06	6,29	0,9	0,01	0,11	4,8
	120—130	0,36	—	—	—	None	4,67	Traces	0,06	4,73	1,3	0,01	0,15	4,5
226	0—10	—	9,41	0,21	—	—	15,50	5,9	—	21,4	—	0,05	0,59	4,7
	20—30	—	3,56	0,19	10,8	—	Not det'd.	—	—	—	—	—	—	3,7
	45—55	—	1,28	0,09	8,3	—	8,0	3,8	—	11,8	—	0,07	0,62	3,9
	125—140	—	—	—	—	—	12,0	3,3	—	15,3	—	0,03	0,47	4,1
367	0—15	4,60	6,92	0,448	9,0	21	18,69	12,46	0,36	31,51	1,1	0,03	0,21	5,2
	30—40	3,44	3,05	0,217	8,2	19	17,13	6,23	0,90	24,26	3,7	0,01	0,23	4,5
	60—70	4,69	4,82	0,284	9,9	25	18,69	4,67	1,68	25,04	6,7	0,03	0,26	4,4
	80—95	3,15	—	—	—	17	14,02	4,67	0,37	19,06	1,9	0,01	0,42	4,4
	120—130	4,26	—	—	—	23	21,84	3,08	0,37	25,29	1,5	0,01	0,11	4,8
	160—170	3,50	—	—	—	21	17,13	4,71	0,10	21,94	0,4	0,01	0,09	4,8
368	0—15	4,01	4,20	0,238	10,2	21	15,57	4,68	0,93	21,18	4,4	None	0,59	4,3
	30—40	3,61	4,17	0,332	7,3	24	12,46	3,11	1,01	16,58	6,1	0,01	0,50	4,4
	70—80	4,04	5,15	0,319	9,4	24	17,13	6,23	1,03	24,39	4,2	0,01	0,26	4,6
	105—115	3,41	—	—	—	21	15,57	6,27	—	21,84	—	None	0,04	4,7
	135—145	4,06	—	—	—	23	20,25	9,34	0,03	29,67	0,3	0,01	0,15	4,8

Note: Comma represents decimal point.

[a] The Profile Numbers are: 369-a forest meadow stratified sandy loam; 226-a dark colored meadow soil (sod-meadow); 367-a meadow gley soil; 368-a meadow bog gley soil. For other profile numbers see Table 4.

Table 4

Group and fractional composition of the humus of upper (0-20 cm) horizons of several soils of the Upper Amur bottom land

Profile No.	Total C (% of soil	% C of alcohol -benzol extract	% C of acid filtrate	C of humic acids, in percent of total C: I	II	III	Total	C of fulvic acids, in percent of total C: I + II	III	Total	C of nonhydrolyzed residue	C of humic acids / C of fulvic acids
366 [a]	2,93	5,11	3,07	17,74	2,74	1,37	21,85	16,04	1,37	17,41	45,05	1,2
371	2,52	6,75	3,57	17,06	9,53	2,38	28,97	17,06	1,19	18,25	35,71	1,6
365	1,37	5,88	4,28	16,57	12,84	1,60	31,01	18,72	2,14	20,86	30,48	1,5
370	2,26	5,75	4,42	19,46	9,30	1,33	30,09	22,12	1,77	23,89	31,42	1,2
372	2,14	6,07	5,14	21,49	9,82	1,40	32,71	21,50	1,40	22,90	27,10	1,4
Oxbow Lake clay	2,92	8,90	3,77	14,38	11,99	2,05	28,42	17,81	1,03	18,84	35,62	1,5

[a] Profile Numbers are: 366 – a dark colored meadow bottom land soil (sod-meadow); 371- a meadow, thick, average humus, bottom land soil; 365 – a meadow stratified, thin, average humus bottom land soil; 370 – a meadow-forest bottom land soil; 372 – a meadow-like forest bottom land soil (primitive forest brown). Analyst Ye. M. Orlov.

Note: Comma represents decimal point.

land. The water of the Amur and of the Oxbow lakes of along the river bottom land has a neutral reaction (pH of 7 and 6.7). The pH value of the oxbow lake water on the high bottom land, which is renewed less often, drops to 6.4. The ground waters of developed bottom land soils formed under excellent drainage conditions (pH 5.6) have the lowest pH values.

The selective adsorption capacity by vegetation, the specific character of humus formation, and the composition of ground waters determine the characteristics of the changes in the adsorption complex of bottom land soils (Table 3). On the whole, the adsorption capacity and composition of exchangeable cations of high bottom land soils show a clear dependence upon the percentage and properties of organic matter, to a lesser extent of the clay fraction. In the upper horizon of forest soil (Profile No. 370) the large total exchangeable cations (to a considerable extent, – ash elements of coarse humus) is responsible for the high percentage of organic matter when there is a low clay content, while in the upper horizon of meadow soil (Profile No. 366), when there is a high humus and clay content, the sum of exchangeable cations is considerably lower. In the meadow-bog and bog soils (Profile Nos. 367 and 368) the relationship between the sum of exchangeable cations and the humus and clay content is the same as in the fresh alluvial deposits. Calcium is predominant as part of the adsorption complex of all soils. The ratio of calcium to magnesium is the widest in the humus horizons, including the buried horizons (for example, Profile No. 367, depth is 120-130 cm) with a maximum in the forest and meadow developed soils (Profile Nos. 370 and 366), with a minimum in the meadow-gley and meadow-bog soils. The ratio of Ca:Mg becomes narrower as we move downwards through the profile of all soils.

In the fresh clay, forest meadow stratified soils (Profile No. 369), there usually exists a very small amount of exchangeable aluminum – a fraction of the percent of the sum of exchangeable cations. During soil formation exchangeable acidity of all soils increases notic ably. A particularly significant increase – u to 5%-6% of the sum – is observed in the fine-textured layers, enriched by alluvial organic matter. The presence of organic matter throughout the entire profile of bottom land soils is responsible for the substantial excess in the amount of exchangeable hydroge over aluminum. The participation of aluminu in the formation of exchangeable acidity increases only in the meadow gley and meadow bog soils with regard to the intensive development of the reducing processes. In the lower horizons of all soils, exchangeable acidity – as a result of the neutralizing action of groun waters – decreases sharply. The exchangeable acidity of the upper horizons of the vario soils depends, apparently, upon the percentag of bases in the litter ash and upon its decompo tion conditions. The lowest exchangeable aci is observed in the upper horizons of meadow and forest soils (Profile Nos. 366, 367, 370); the greatest exchangeable acidity is seen in the meadow bog soils (Profile No. 368). A change in the pH of the salt suspension throug out the profile also enables us to observe the highest exchangeable acidity in the central pa of the profile of meadow and forest soils, and the upper part of the profile of meadow bog so

In studying the transformation of the clay fraction of alluvial deposits in the soil develo ment process, we should point out that bottom land soil formation occurs simultaneously an is closely allied with the geological and geochemical processes of forming a transit – accumulative weathering crust (9), in which, along with a partial accumulation of available

Table 5

Chemical composition of soil and ground waters in the Amur bottom land (vicinity of Kumara), mg per liter

Sampling date	Source	Sum of ions	pH	Total alkalinity of HCO_3	Cl	SO_4	Ca	Mg	Na	K	SiO_2	Fe_2O_3	Al_2O_3	HCO_3	SiO_2
														% of total ions	
Aug. 8, 1957	Amur River	74,7	7,0	53,7	2,5	5,0	7,0	2,6	3,9	1,0	10,7	0,14	0,01	70	14
"	Oxbow lake along the river bottom land	—	6,7	78,1	2,5	—	14,6	3,9	—	—	2,1	0,29	0,01	—	—
"	(the same)	—	6,8	58,6	2,5	—	8,6	2,0	—	—	10,7	0,43	0,01	—	—
"	Ground water of meadow soil, along the river btm. ld.	80,7	5,6	43,9	2,5	16,4	8,8	1,1	4,0	4,0	16,1	0,43	Not det'd.	54	20
"	Oxbow lake on terraced bottom land	60,6	6,4	43,9	2,5	5,0	3,8	3,5	1,9	1,0	16,1	0,57	0,01	72	26
"	Grd. water of mead.-bog soil, same place	74,1	5,6	48,8	1,3	8,2	8,0	1,3	4,3	2,2	10,7	0,72	0,01	65	14
June 30, 1956	Ground water of peat gley soil, same place	104,3	6,4	78,2	1,4	None	14,0	4,9	3,7	2,1	16,0	0,73	0,01	75	15

Note: Comma represents decimal point.

compounds, periodic sedimentation of fresh new material is most important. The rate and frequency of periodic restoration of bottom land surfaces decrease from low to high levels; at the same time the length of the period of soil formation undisturbed by alternating flood states increases. Thus, in the profile of bottom land soils the older layers are changed toward the surface by young deposits which undergo far greater intensive and profound changes during the soil-formation process.

The mineralogical composition of fresh clay at the forest-meadow stratified soil stage (Profile No. 369) is preserved practically intact. In the meadow forest soils of broadleaf forests (Profile No. 370) we observe a slight decrease in the percentage of iron montmorillonite (nontronite) down through the profile, with a decrease in the extent of its crystallization. This phenomenon is clearly expressed in the meadow-gley and meadow-bog soils. In the meadow-gley soils of reed-grass meadows (Profile No. 367) a faintly crystallized montmorillonite has been detected only in the upper horizon. Below there is none. In the highest level dark colored meadow soils we failed to detect montmorillonite. Thus, we see as typical of the bottom land soils of the temperate zone the hydromica formation of the clay fraction stimulated by a high potassium content in the natural waters and in the ash of bottom land vegetation, and occurring when the reaction of the medium is weakly acid or neutral. The hydromicas are the principal minerals of the clay fraction of Amur bottom land soils, and are considerably kaolinized. In excessively wet soils we should mention the increase in the degree of kaolinization of the soil mass down through the profile, which is associated, apparently, with lower pH values.

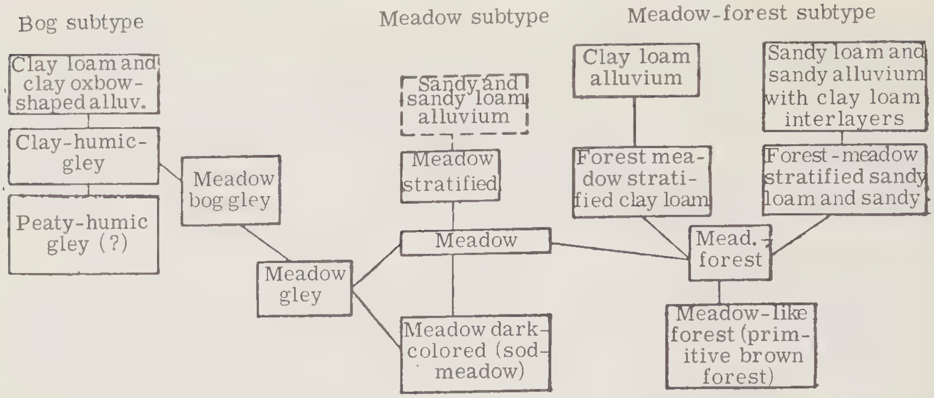
The difference is soil-formation processes in the bottom land enables us justifiably to separate the meadow, meadow-forest, and bog soils, considering the tendency of their development, into independent groups. The need of such a division for bottom land soils of European USSR has been stated variously by Prasolov (14); Kovda (8); Vladychenskiy (2); Shrag (16); Dobrovol'skiy (5); Yegorov (6), and others.

These groups have been divided according to the extent to which the basic process (scheme) has been expressed.

For the soils of the meadow subtype developed on the highest levels of bottom land we have adopted the name "sod-meadow" (meadow dark-colored) representing a subgroup, considering the sharply increasing role of atmospheric moisture and the lesser degree to which the ground waters participate in the formation of these soils. At the same time we have distinguished these soils from the sod-meadow soils of the Amur terraces ("the chernozem-like soils of prairies" — "the meadow dark colored" [9]). These latter soils are formed under special hydrogeological conditions; the ground waters here are at a depth of 8-15 m.

1. The meadow-forest bottom land soil formation is aided partly by trees, and in most cases, by grass vegetation under atmospheric

Scheme of Upper Amur Bottom Land Soil Development


Bog subtype
Meadow subtype
Meadow-forest subtype
Clay loam and clay oxbow-shaped alluv.
Clay-humic-gley
Peaty-humic gley (?)
Meadow bog gley
Meadow gley
Sandy and sandy loam alluvium
Meadow stratified
Meadow
Meadow dark-colored (sod-meadow)
Clay loam alluvium
Forest meadow stratified clay loam
Sandy loam and sandy alluvium with clay loam interlayers
Forest-meadow stratified sandy loam and sandy
Mead.-forest
Meadow-like forest (primitive brown forest)

ground and high water moisture conditions.

In the forest-meadow stratified bottom land soils along the river beneath willow thickets and willow forests, the genetic horizons are not developed. The sandy and clay loam soils are distinguished by the texture of the upper layer of alluvial deposits. Clay loam soil formation is aided by reed grass; they are potentially more fertile. After Amur flow has been regulated, the stratified soils may be used for meadows or for the planting of rapidly growing trees.

The upper part of the profile of meadow-forest bottom land soils of elm forests having a sparse grass cover has been appreciably altered by soil formation. The ground waters are 2-3 m deeper. After regulating flow of river these soils may be used for forest plantings, meadows, gardens, and orchards.

The meadow-like forest bottom land (brown forest primitive) soils of mixed broadleaf forests having a grass cover. The alluvial texture is preserved only in the lower part of the profile. The role of floods in the soil formation is small; the ground waters are 4-5 meters deeper. They may now be used for various local agricultural crops.

2. The meadow bottom land soil development is aided by meadow vegetation under atmospheric, ground water and floods.

The meadow bottom land, stratified, average humus, thin, and medium thick soils of the low bottom land replace the meadow-forest soils of willow forests. Their independent formation was not ruled out, but we did not directly observe this.

The meadow bottom land soils of grass meadows are associated with flat expanses of high bottomland; at the surface they are made up of clay loams. Thick and medium thick, average humus soils (humus content not greater than 5%) are predominant. Good garden soils, suitable for planting orchards, grain, and commercial crops which are favored by the level and flat relief of large areas.

The meadow dark colored bottom land soils of highest levels. At the surface they are clay loams and coarse clay. Humus content is 6%-8%. They are formed under natural highly productive legume and mixed grass meadows. May be used for haying or gardens and orchard

3. The meadow-bog (bog?) bottom land soil of oxbow-shaped sedge-reed grass water logge meadows (bogs). They are formed during exce surface water, ground water and frozen moisture. They are characterized by initial stages of lowland peat accumulation in the form of hummocks and slightly mineralized plant residue. Distinguished are: 1) the clay humic gley bottom land soils on the periphery of dried up oxbow lakes in the initial phases of surface development; and 2) meadow-bog gley bottom land soils of water logged meadows. After the water flow has been regulated, these soils will require additional drainage while the soils of water logged meadows will require surface levelling after which they can be used for highly productive meadows.

We must point out that in these bottom lands we failed to find sedge lowland bogs having peaty-humic-gley soils (although we did not rule out the possibility of their development). Obviously, this was due to the over-all geological youngness of the upper Amur bottom land, and to the dynamism of the bottom land surface.

There are 92,000 hectares of bottom land soils at the upper course of the Amur, from the village of Pokrovka to Blagoveshchensk; at the middle course from Blagoveshchensk to the mouth of the Sungari there are 483,000 hectare (3). This large land area, containing a high natural fertility, has an unfavorable water regi caused by spring floods from the Amur. After the Amur flow has been regulated it may be possible to use actively the bottom land soils for agriculture, for such as meadow cultivation, gardening, and truck farming, and, in places, for grain and commercial crops.

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CHARACTERISTICS OF SOILS OF THE KARGOPOL'SKAYA DRY LAND

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General Characteristics

The name "Kargopol'skaya Dry Land" relates to the period when Kargopol' played an enormous role in the trade relations between Vologda and Belozersk, on the one hand, and the Onega River, on the other (6). This name has been preserved not only among the local population, but has been incorporated into geography and soil science literature. However, the data available in literature on the extension of "the dryness" and its natural characteristics is inconsistent and vague. Detailed studies of the geological structure of this region (Amalitskiy, 1897; Borisov, 1910; Barkhatova, 1941; Inostrantsev, 1870-1872; Konradi, 1913; Murchison, 1894; Sobolev, 1901; Tolstikhin, 1921-1923; and others) have shown that the carboniferous beds are deposited here directly on Devonian deposits and are divided into two layers: the upper lime layer and the lower sandy-clay layer of variegated color.

The first soil studies which more or less accurately deal with the boundaries of "the dry land" and the character of soil formation here, were carried out by Krasyuk (3) and Zonn (1938).[1] These investigators point out that the Kargopol'skaya dry land covers the left bank of the Onega River, about 30 kilometers wide. According to Tatarinov (7) the northeastern part of the Onega River basin is united with the Nyandomskiy Region. Tatarinov assigns the entire remaining portion of the river basin to the Kar'gopol'skiy Administrative Rayon, where podzolic and sod-podzolic soils predominate. Thus, Tatarinov does not distinguish the Kargopol'skaya dry land as an independent natural specific region southwest of Arkhangel'skaya Oblast', but identifies it with other regions which differ sharply from it in natural conditions.

In 1957 we made field studies of soils in the upper and central parts of the Onega River basin.[2] The Kargopol'skaya dry land situated at the upper course of the Onega River basin, differs in natural conditions from the adjacent districts of this area and should be regarded as an independent natural region. It originates in the southwest part of Lake Lacha, running westward along the Likshma River; from the central course of this river the boundary of dry land swerves northward towards the Kena River. Here it intersects the Onega River and stretches eastward along its left bank 60-80 kilometers, then descends southward and approaches the Voloshka River in the form of a comparatively narrow strip. Further down this boundary widens and runs along the eastern shore of Lake Lacha.

The Kargopol'skaya land embraces a compa atively small area. In natural conditions it m be distinguished as a special biogeochemical province. The native rocks in the basin of the upper reaches of the Onega River belong to the carboniferous age while in the southeast these rocks are identified with a Permian age and are different kinds of carbonate deposits by which the Quaternary alluvial deposits were also enriched; their thickness varies here between 5 and 15 m. The thickness of the alluvial deposits increases as we move east and west of "the dry land," and in the region of the Nyandomskaya terminal moraine strip, the Konozerskaya highlands, they are of considerable size. In texture, the glacial drifts of "the dry land" are noted for their significant variegation. In the southern part they are more sandy, while in the northern part clay loams predominate. The Quaternary alluvial deposits enriched by carbonates, which occasionally crop out, and the flatness of the country (we see a depressio only towards the Onega and Voloshka Rivers) also determine the vegetation character and trend of soil formation development which are unique in Northern Europe. Here in the pine and mixed coniferous forests is a well-developed grass cover, in the midst of which red clover is very often predominant; we often encounter bitter vetch, lungwort, elm leafed spiraea, and soddy reed grass or sedge, that is, plants typical of the southern taiga subzone. We do not find these plants in overmature spruce forests, but there is a predominance of green moss and tough-leafed taiga semi-shrubs — the whortleberry. Forming the surface vegetation of the temporary deciduous forests are also grasses among which re is especially much red clover.

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[1] We became familiar with the city of Kargopol' from a manuscript account of a study of soils in the Kargopol'skiy region and from a soil map by S.V. Zonn.

[2] V.V. Ponomareva participated in the field studies in addition to the author.

From data of the Kargopol' Meteorological ion, the mean annual air temperature tuates between 1.8 and 2.3°C, while pre-itation in the course of a year totals 467- mm. In the spring, precipitation is about 85 mm; in the summer, 210 mm; in the , 115 mm; and in the winter, 70-75 mm.

s and their Physicochemical Characteristics

We find on the Kargopol'skaya land podzolic, -podzolic and humic-carbonate soils. The zolic soils on carbonate deposits are usually nd beneath over-mature spruce forests hav- a well-developed green moss cover. In se forests the soil-formation process is he podzolic type. Here, depending upon extent to which the moss cover is developed, carbonates are leached to different depths beneath a cushion of moss lies a clearly eloped podzolic horizon, the thickness of ch is often 10-15 cm. Consequently, the sence of carbonates in the soil-forming ent materials does not prevent the aggres- e action of acid organic products under the rothermic conditions of the Kargopol'skaya l. An intensive decomposition of minerals es place and the decomposition products are ried off into the lower-lying soil horizons.

The podzolic process is not evident beneath porary deciduous forests, formerly culti- ed shrubs, and on old plowed strips. The zolic horizon, in most cases, is absent or ears as a small zone — a residual podzolic izon. The soil-formation process is devel- d following the sod type. We shall assign plowed soils to the humic carbonate type. d out and described are soil profile num- s on the old plowed strip (Profile No. 2) in deciduous forest (Profile No. 9), and in the ıce forest (Profile No. 99).

Profile No. 2. Laid out on old plowed strip theast of Nadporozhskiy village. A plain. th of profile 130 cm. Humic carbonate on carbonate coarse clay loam.

$_{\text{plowed}}$ 0-10 cm. Dark-gray clay loam, per- ted by plant roots. Transition gradual.

$_{\text{plowed}}$ 10-30 cm. Lighter color, clay n with less root residue. Transition rly expressed.

$_1$ 35-45 cm. Pale yellow, with isolated wnish spots. A more compacted structure. nsition clearly expressed.

$_2$ 50-60 cm. Cinnamon-brown clay loam, pact (dense) structure becoming prisma- nits. Transition gradual.

$_3$ 60-70 cm. Coarser structure clay loam ompared with B_2 horizon. Small-sized estone pieces found. Transition gradual.

$_4$ 80-90 cm. More compacted carbonate loam.

100-120 cm. Carbonate clay loam.

rofile No. 99. Laid out in an old spruce forest north of Arkhangel' village. Surface vegetation cover is a thick cushion of green moss, whortleberry, and red bilberry (foxberry). Depth of profile is 100 cm. A strongly podzolic soil on carbonate clay loam.

A_0 0-3 cm. Vegetation consisting of green moss and whortleberry.

A_0-A_1 3-7 cm. A semi-decomposed coarsely-humified vegetation permeated by forest and semi-shrub roots. Transition clearly expressed.

A_2 7-15 cm. Light gray coarse clay loam; compact structural profile. Isolated large tree roots found. Transition clearly expressed.

B_1 15-25 cm. Cinnamon-brownish clay loam; friable structure. Large roots found. Transition gradual.

B_2 35-60 cm. Compacted homogeneous more fine clay loam. Lighter color in the upper part of the horizon; carbonates found in the lower part. Transition into soil-forming parent material gradual.

C 70-90 cm. Carbonate clay loam.

Profile No. 9. Laid out on right bank of Onega River south of Oshevenskoye village. Birch forest with admixture of aspen. Ground vegetation of raspberry, reed grass, willow herb, clover, and other grasses. No moss. Depth of profile 90 cm. A sod weakly podzolic soil on carbonate clay loam.

A_0 0-3 cm. A sod horizon strongly intertwined with plant roots.

A_1 3-15 cm. A humified horizon, dark gray, friable structure, sandy loam. Plant roots found. Transition clearly expressed.

A_2 15-20 cm. Light yellow, friable, sandy loam. Inclusions of iron concretions found. Transition clearly expressed.

B_1 20-30 cm. Finer textured clay loam. Roots found. Transition gradual.

B_2 30-40 cm. Differs from B_1 horizon by only more brownish color. Transition gradual.

B_3 40-50 cm. Same clay loam as in B_2 horizon, but abundantly enriched with limestone fragments.

B_4 50-60 cm. Coarser textured-sandy loam with many limestone fragments.

C 70-80 cm. A carbonate silty sandy loam.

Results of particle-size analyses (Table 1) confirm earlier expressed views that soils and soil-forming parent materials in the northern Kargopol'skaya land are characterized by a finer texture than those found in the southern part. As seen from Table 1, the sum of particles <0.01 mm in diameter in the soil-forming parent material is 47% (Profile No. 99), whereas soils of the southern part of "the dry land," have fewer of these particles but their distribution throughout the individual hori-

Table 1

Particle-size analysis of the soils of the Kargopol'skaya land expressed in percent of total fine earth

Profile No.	Horizon	Depth, cm	Amount of coarse earth	Solution loss fr.HCl	Particle diameter, mm						
			in percent		1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	< 0,001	< 0,01
2	A_{plwd}	0—10	0,44	3,00	5,80	33,62	28,79	9,17	14,50	5,12	28,79
	A_0	10—30	0,64	2,83	6,54	27,81	33,62	8,92	14,65	5,63	29,20
	B_1	35—45	0,40	3,70	4,12	21,74	33,48	6,49	11,84	18,63	26,96
	B_2	50—60	0,20	7,18	2,93	10,79	22,34	16,77	19,78	20,21	56,76
	B_3	60—70	2,52	32,54	12,08	23,74	10,82	5,77	4,33	10,72	20,82
	B_4	80—90	3,24	28,05	8,40	34,00	8,66	10,09	2,24	8,56	20,89
	C	100—120	11,28	30,06	11,10	27,18	12,56	3,88	5,58	9,70	19,16
99	A_2	7—15	1,30	1,64	12,11	38,03	26,66	9,27	9,17	3,12	21,56
	B_1	15—25	0,78	2,89	5,87	26,03	34,58	9,42	14,88	6,28	30,58
	B_2	35—60	1,26	4,55	5,53	23,00	17,40	8,49	19,98	21,00	49,47
	C	70—90	4,16	10,80	6,03	29,45	11,10	6,08	17,25	24,29	47,62
9	A_1	3—15	3,42	2,60	9,94	31,71	33,24	8,29	11,24	2,93	22,46
	A_2	15—20	5,86	2,62	0,47	46,34	20,49	8,02	11,97	8,09	28,08
	B_1	25—30	5,00	4,89	9,10	27,07	17,39	9,29	10,02	22,24	41,55
	B_2	30—40	4,58	6,26	8,09	27,06	15,77	6,83	14,53	21,46	42,82
	B_3	40—50	4,48	26,32	6,70	14,86	19,42	3,96	6,37	22,33	32,66
	B_4	50—60	18,06	29,45	8,23	11,22	26,49	5,48	10,13	9,00	24,61
	C	70—80	15,64	31,95	7,14	28,66	6,70	4,64	9,89	11,02	25,55

Note: Comma represents decimal point.

zons of soil layer are more uneven.

In the illuvial horizons of these soils there is considerable accumulation of clay particles (<0.001 mm in diameter) with a considerably smaller amount in the upper horizons and in the parent materials. Such a nature of clay particle distribution can be explained by the rate of soil-formation development, especially when these soils were under spruce forests. The fine clay particles undoubtedly are removed from the upper horizons and accumulated in the lower-lying horizons.

As we can see from Table 1 there is no great difference in the distribution character of the coarser particles throughout the individual horizons of these soils. The sandy-silty particles are predominant. Their total varies between 50%-70%. Such a texture is beneficial to the water and chemical properties of soils, especially to carbonate soil-forming parent materials.

Chemical analyses of soils (Table 2) indicate that vegetation greatly affects the accumulation and distribution character of humus and the exchangeable bases, and the reaction of the soil suspension. The entire area of "the dry land" was covered formerly by a spruce forest having a well-developed moss cover, the role of which in changing soil chemistry can be seen by examining the soil of profile No. 99. Here, simultaneously with the accumulation of exchangeable bases (72-83 meq per 100 grams of soil) we see a high active and exchangeable acidity in the forest litter and mineral horizons of the soil. We observ an increase in pH values only in the soil-forming parent material, which is enriched by calcium carbonates. Besides, the semi-decomposed plant residue (horizon A_0-A_1) and the podzolic A_2 horizon are characterized by a greater acid reaction (salt pH 3.30-3.90) as compared with the A_0 horizon. Consequent the principal role in calcium carbonate leachi and in the development of podzol formation in soils is attributed to the acid decomposition products formed during decomposition of the moss cover in this horizon. In these soils we find almost throughout the entire profile a large amount of exchangeable aluminum and hydrogen ions which is also responsible for the soils' high activity. The accumulation in upper horizons of exchangeable bases is associated with their biological accumulation. The percent of exchangeable bases decreases markedly with depth and only at a depth of 50-60 cm, with the appearance of carbonates, is their value greater than 12 meq per 100 gram

Table 2

General chemical characteristics of the soils of the Kargopol'skaya Land

Profile No.	Horizon	Depth, cm	Humus	Nitrogen	pH		Exchangeable Bases						Available forms	
			%		H_2O	KCl	H	Al	H + Al	Ca	Mg	Ca + Mg	P_2O_5	K_2O
							In meq per 100 grams of soil							
2	$A_{\text{plwd.}}$	0—10	3,44	0,17	7,70	6,70	—	—	—	11,47	6,90	17,37	2,50	8,00
	$A_{\text{plwd.}}$	10—30	2,31	0,11	7,70	6,70	—	—	—	11,36	6,00	16,36	1,25	8,00
	B_1	35—45	0,[illegible]7	0,04	7,80	6,70	—	—	—	10,00	6,90	16,90	1,25	5,00
	B_2	50—60	0,93	0,05	8,00	6,70	—	—	—	—	—	—	2,50	0,00
	B_3	60—70	—	—	8,40	7,40	—	—	—	—	—	—	—	—
	B_4	80—90	—	—	8,50	7,70	—	—	—	—	—	—	—	—
	C	100—120	—	—	8,60	7,70	—	—	—	—	—	—	—	—
99	A_0	0—3	57,35[a]	1,84	5,60	5,10	1,68	2,51	4,19	76,52	7,22	83,74	20,00	67,00
	A_0/A_1	3—7	67,17[a]	2,03	4,90	3,90	1,29	1,51	2,80	68,30	4,13	72,43	20,00	33,00
	A_2	7—15	1,13	0,05	4,40	3,30	0,16	2,91	3,07	1,30	0,58	1,88	7,50	25,00
	B_1	15—25	0,99	0,04	5,40	4,10	0,02	1,97	1,99	1,50	1,24	2,74	2,50	20,00
	B_2	35—60	—	—	5,60	4,10	0,02	0,94	0,96	7,62	5,18	12,80	2,50	20,00
	C	70—90	—	—	7,50	6,90	—	—	—	—	—	—	1,25	13,30
9	A_0	0—3	87,10[a]	2,83	6,10	5,40	0,72	0,34	1,06	58,90	5,02	63,92	7,50	—
	A_1	3—10	2,80	0,12	5,30	4,00	0,05	1,09	1,14	2,72	1,48	4,20	1,25	11,10
	A_2	15—20	0,63	0,03	5,90	4,40	0,00	0,75	0,75	3,40	2,06	5,46	2,50	8,00
	B_1	25—30	0,83	0,04	5,90	4,30	—	0,42	0,42	—	—	—	1,25	7,00
	B_2	30—40	0,98	0,05	7,10	6,40	—	—	—	—	—	—	1,25	8,00
	B_3	40—50	0,42	0,02	8,40	7,20	—	—	—	—	—	—	—	—
	B_4	50—60	—	—	8,50	7,50	—	—	—	—	—	—	—	—
	C	70—80	—	—	8,60	7,60	—	—	—	—	—	—	—	—

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[a] Ignition loss

Note: Comma represents decimal point.

Table 3

Total chemical composition of the soils of the Kargopol'skaya Land, % of ignited sample

Profile No.	Horizon	Depth, cm	Ignition loss, %	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	MnO	CaO	MgO	SO_3	K_2O	Na_2O	Total	$\frac{SiO_2}{R_2O_3}$
2	Aplwd.	0—10	4,39	76,35	12,66	3,13	0,80	0,20	0,06	2,12	1,32	0,21	1,67	1,84	100,36	8,86
	Aplwd.	10—20	4,20	76,40	12,66	3,11	0,76	0,26	0,03	1,90	1,30	0,14	1,97	1,83	100,42	8,87
	B_1	35—45	3,17	73,00	14,98	4,63	0,79	0,19	0,08	1,57	1,54	0,14	1,07	1,63	99,00	6,92
	B_2	50—60	4,78	67,65	17,48	5,99	0,43	0,19	0,11	2,07	2,42	0,17	1,85	1,59	99,92	5,41
	B_3	60—70	15,66	61,05	11,43	3,24	0,55	0,12	Trace	12,38	8,31	0,25	1,99	1,06	100,38	7,69
	B_4	80—90	19,86	65,07	10,25	2,65	0,23	0,17	"	11,55	7,11	0,28	1,18	1,50	99,99	9,25
	C	100—120	13,76	62,90	11,09	3,08	0,23	0,14	0,05	12,74	6,62	0,23	1,87	1,32	100,27	8,18
99	A_0	0—3	57,35	68,17	11,82	5,53	0,56	0,11	0,16	5,99	3,20	0,79	1,91	1,47	93,70	9,85
	A_0/A_1	3—7	67,17	77,00	8,15	5,15	0,94	0,48	0,18	3,60	1,50	0,94	2,30	1,52	100,48	16,37
	A_2	7—15	2,29	83,66	5,54	3,14	0,74	0,02	0,03	1,28	0,56	0,07	1,68	1,43	100,15	16,22
	B_1	15—25	3,24	75,60	12,78	4,17	0,81	0,02	0,03	1,51	1,26	0,12	1,94	1,63	99,90	8,31
	B_2	35—60	4,18	70,00	15,03	5,53	0,86	0,08	0,04	2,32	1,09	0,43	2,09	1,57	100,06	6,46
	C	70—90	7,21	70,16	13,71	5,16	0,74	0,05	0,04	3,68	3,60	0,12	1,47	1,36	100,09	7,66

Note: Comma represents decimal-point.

of soil. There is little available phosphor acid in the soil but there is a large amoun potassium.

The soil of Profile No. 9 differs signif cantly from the soil under spruce forests. Formerly this strip was used for agricultural crops, then was abandoned, and nov is under a 30-40 year old birch forest hav ing vegetation consisting of grasses and clover. Such a vegetative character has contributed not only to the formation of a sod layer and to humus accumulation, but also to the biological accumulation and fixation of exchangeable bases in the uppe soil horizons, to a decrease in active and exchangeable acidity, as compared with s under a spruce forest.

This is particularly evident from the e ample of plowed soil in Profile No. 2. Humus, nitrogen, and exchangeable bases accumulate in the upper horizon of this soil. The reaction of the water and salt suspension throughout the entire depth of the profile number is almost neutral. Consequently, when the moss cover is replaced by a grass mixture there takes place the formation of secondary humic carbonate soils, while the root system favors the fixation of exchangeable bases in the upper horizons of the soils. In plowed soils, as in soils under birch forests, there is a small amount of available forms of potassium and phosphorous. Th application of these mineral fertilizers should have a positive effect on the growt and yield of agricultural crops.

T. V. Aristovskaya's microbiological studies of the upper horizons (0-20 cm) of soils in Profile Nos. 2 and 9 show that th plowed soils are characterized by a more active microflora as compared with soils under forests. Such bacterial groups (wh are important, agronomically speaking) a the nitrifyers, aerobic cellulose-decompo ing bacteria, and anaerobic bacteria, are in far greater numbers in the plowed soil than in the soils under forests. These ba terial groups are very exacting in their mineral nutrient requirements and indica that there are far more mineral nutrient elements in the plowed soils of the Kargopol'skaya land than in the soils covered b forests.

The total chemical analyses given in Table 3 confirm the different soil-formati character in the forest and plowed soils. Beneath a spruce forest (Profile No. 99) soil formation is developed after the podzolic type, with mineral decomposition and intensive removal of decomposition products from the upper horizons into the lower-lying horizons. This is particular well noted by the accumulation in the pod A_2 horizon of total SiO_2 (83%) and by the smaller amounts of other oxides. Sesqui oxides, calcium, and magnesium are particularly intensively removed. The total sesquioxides in the A_2 horizon is half tha in the B_1 horizon, and in the soil-forming parent material. A more or less develop oxide accumulation by vegetation does no nly prevent the podzol formation process but oes not even camouflage it, which well orroborates the total chemical analysis of oil in Profile No. 99.

We observe a totally different soil-forma- on trend in the plowed soil (Profile No. 2). ere, we see no developed oxide migration rough the soil layer. Only in the plowed orizon do we see an accumulation of SiO_2 and decrease in the amount of sesquioxides as ompared with the B_1 horizon. Possibly, such distribution is the result of an earlier soil- ormation development when the strip was overed by forests and it followed the podzolic ype. Although the podzolic horizon was de- troyed by cultivation, its characteristics have till been preserved in the form of an increase n the content of SiO_2 in the plowed layer. A ertain accumulation of ferric and aluminum xides in the B_2 horizon may be associated ith an increase in the amount of fine clay articles, and with the rate of soil formation evelopment in the past, when the strip was overed by spruce forests.

There is a large amount of SO_3 in the Kargo- ol'skiye soils. Especially noteworthy in this espect are the upper soil horizons in Profile o. 99 where the amount of SO_3 varies between .97% and 0.94%. Although the amount of SO_3 ecreases with depth, there is 0.28%-0.43% in e individual soil horizons. This may be ex- lained by the fact that there is a widespread istribution in the Arkhangel'skaya Oblast' of ypsiferous rock outcrops from the fragments f which the moraine deposits, too, may have ecome enriched in the glacial period.

By comparing our data on the characteris- cs of the Kargopol'skiye soils formed on arbonate deposits, with date of Domracheva) Lebedev (4), Tikheyeva (8, 9), Ponomareva d Myasnikova (6) on the characteristics of oils of the Siluriyskoye plateau, it should be oted that under the natural conditions of the argopol'skaya land carbonates are leached ore intensively in the soils under forests an in the soils of the Siluriyskoye plateau d soils of the Kaliningradskaya Oblast' (2).

Conclusions

1. The Kargopol'skaya land covers a rather mall area and by its natural conditions may e assigned a special biogeochemical province.

2. The "dry land" is made up of a limestone yer associated with the carboniferous age. his limestone also enriched the Quarternary luvial deposits with calcium carbonates.

3. Carbonate effect on soil formation is een in the character of vegetation. In spruce seen in the character of vegetation. In spruce forests having a well-developed moss cover the carbonates are leached to a considerable depth and soil formation follows the podzolic type.

4. Under the temporary deciduous forests having surface vegetation consisting of a mixture of clover and grasses, soil formation follows the sod type.

5. The plowed soils belong to the secondary humic carbonate type, often effervescing at the surface and resembling the soils of the Siluriyskoye plateau in structural profile and chemical composition.

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MANTLE CLAY LOAMS OF THE SOUTHEASTERN AND CENTRAL PARTS OF THE RUSSIAN PLAIN AS SOIL-FORMING PARENT MATERIAL

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Mantle clay loams occupy large areas in the southeastern and central parts of the Russian Plain. Since they are widespread and many of their properties are inherited by the overlying soils, their study is of great practical importance and is of theoretical interest because old soil-formation processes could have played an important part in their origin.

This article discusses these problems on the basis of a comparative study of mantle and morainic clay loams and soils in the Vologda Region. The conclusions derived from it are valid to a large degree for the southeastern and central parts of the Russian Plain, because of the similarity of the mantle deposits in this area. As analytical data show (Table 1), samples of mantle deposits taken at various locations are characterized by a very close total chemical composition.

The SiO_2 and sesquioxides predominate in the total chemical composition of these mantle deposits, while the content of alkali earth bases ($CaO + MgO \simeq 3\%$) is low. The SiO_2 content varies 71%-74%, and mantle clay loams containing 73% SiO_2 predominate. The lower values may be associated with the carbonate content of the deposit (for instance, Profile 34 contains 71.4% SiO_2), or with its somewhat coarser texture. Coarser-textured mantle deposits have a high silica content, as a rule. As has been said earlier, mantle clay loams may differ in texture, but are similar in the predominance of silt fractions, especially coarse silt (0.05-0.01 mm in diameter), and a high clay content.

Our comparative study of mantle clay loam and the underlying moraine showed a similarity between their particle size, chemical, and mineralogical composition.

Structureless, yellowish-brown, silty mantle clay loam was taken from a depth of 150-160 cm, while carbonate morainic boulder clay loam was taken at a depth of 320-330 cm from Profile 15. Profile 15 was made on a terraced slope with an absolute elevation of 130 m. Thick mantle clay loam (2.5 m) in the profile gradually changes into the moraine. Mantle clay loam effervesces at a depth of 230 cm and small boulders begin to appear at this depth, the number and size of which increase with depth.

In comparing the particle size of the mantle clay loam and that of the moraine (Table 2) one notices that the samples differ in their content of coarse separates, while their content of particles <0.01 mm diameter (about 30%) is similar and their content of particles <0.001 mm diameter (21.24% in the mantle clay loam and 17.04% in the moraine) is comparatively close. The coarse silt (0.05-0.01 mm in diameter) content in the mantle clay loam is 52.4%, while in the morainic clay loam it is only 15.1%. In addition, 1-0.25 mm diameter separates are almost completely absent in the mantle clay loam, while they amount to 7.02% in the morainic clay loam; there are less of the 0.25-0.05 mm diameter particles in the mantle clay loam than in the morainic clay loam. These differences are apparently closely related to the carbonate content in the moraine (losses on treatment with HCl are 29.66%), contained primarily in the coarse fractions.

As may be seen from the data (Table 3), mantle and morainic clay loams have almost an identical chemical composition. The only difference is that morainic clay loam contains more free carbonates, so that the SiO_2 content is lower, and a higher content of earth alkali bases as compared to mantle clay loam. This agrees with data given in the work of Koss vich and Krasyuk (7).

The results of mineralogical analysis[1] of the 0.05-0.01 mm diameter fraction of mantle and morainic clay loam from the Vologda Region are given in Table 4 and show that both deposits have a similar petrographic composition, with only different quantitative relationship between minerals.

The latter is expressed first of all in the higher quartz content and lower feldspar content in the mantle clay loams as compared to the moraine. Both samples are characterized by a low content, but a great variety of heavy mineral fractions. As was to be expecte their content is somewhat higher in the moraini boulder clay loam.

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[1] The mineralogical analysis was made by Ye. N. D'yankonova at the Leningrad State University im. Zhdanov.

Table 1

Total chemical composition of mantle deposits

Profile No. and its location	Depth, cm	In percent of ignited mineral mass										
		SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	TiO_2	CaO	MgO	MnO	Na_2O	K_2O	SO_3
270, Komi ASSR	150—160	72,76	14,74	4,17	0,127	1,01	1,53	1,40	0,076	—	—	—
13, Vologda Oblast'	120—130	73,00	16,48	3,83	0,04	—	1,57	1,73	0,09	—	—	0,07
34, Same	145—150	71,45	13,61	4,70	0,01	0,75	3,05[a]	2,46[a]	0,31	1,53	2,13	0,05
35, same	140—145	73,99	15,20	4,71	0,623	—	1,54	1,45	0,38	—	—	—
188, Same	113—118	73,79	13,32	5,23	0,019	0,78	1,46	1,47	0,26	1,71	1,89	0,07
46 (Ye. N. Ivanova), Vologda Oblast'	150—160	71,34	13,20	8,31	0,11	0,91	1,36	1,91	0,07	0,98	1,76	0,16
80 (A. A. Zavalishin), Moscow Oblast'	140—150	73,09	13,05	6,05	—	—	0,98	1,52	0,06	—	—	—
11 (K. V. Verigina), Moscow Oblast'	170—176	73,83	14,44	5,86	0,13	—	1,28	1,65	0,05	—	—	—
3 (A. A. Zavalishin), Vladimir Oblast'	130—140	73,94	12,66	5,64	0,15	1,62	1,11	1,40	0,10	—	—	—
7 A. A. Zavalishin), Vladimir Oblast'	145—150	73,33	12,38	4,74	0,14	1,60	1,97	1,65	0,09	—	—	—
95 (K. A. Ufimtseva), Kostroma Oblast'	150—160	74,92	13,10	6,45	0,11	0,52	1,23	2,13	0,07	0,67	1,76	0,16
86 (K. A. Ufimtseva), Kostroma Oblast'	100—110	71,13	14,88	6,80	0,16	0,74	1,31	2,12	0,07	0,82	1,98	0,23
10 (A. A. Zavalishin), Tula Oblast'	160—170	74,08	14,71	5,92	0,086	—	0,98	1,31	0,08	—	—	—

[a] The high content of CaO is associated with the presence of carbonates.

Note: Comma represents decimal point.

Table 2

Results of particle-size analysis of mantle clay loam and moraine according to the N. A. Kachinskiy method, %.Profile 15

Deposit	Depth, cm	Hygroscopic moist.	Loss on treatmt. with HCl	Particle diameter, mm						
		in %		1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,01	<0,001
Mantle clay loam	150—160	2,61	3,66	0,26	13,06	52,41	3,45	5,95	30,64	21,24
Morainic boulder clay loam	320—330	2,16	29,66	7,02	18,27	15,12	4,09	8,80	29,93	17,04

Table 3

Total chemical composition of Profile 15 (Marfino uchkhoz, Vologda district)

Deposit	Depth, cm	Hydroscopic moisture	Ignition loss	In percent of ignited mineral mass										
		In percent		CO_2	SiO_2	R_2O_3	Al_2O_3	F_2O_3	P_2O_5	TiO_2	MnO	CaO	MgO	Σ
Mantle clay loam	150—160	2,00	3,38	0,02	76,37	14,42	10,90	2,86	0,08	0,65	0,05	1,04	0,94	94,82
Carbonate boulder clay loam	320—330	1,79	8,13	6,74	65,27	16,81	12,19	3,87	0,13	0,62	0,11	6,01	4,24	94,23

Table 4

Mineralogical analysis (immersion method) of the 0.05-0.01 mm diameter fractions. Profile 15

Deposit	Depth, cm	Heavy fraction	Light fraction						Heavy fraction										
			Quartz	Feldspar	Rock fragments	Mica (muscovite)	Chlorite	Ore	Garnet	Zircon	Tourmaline	Rutile	Anatase	Sphene	Minerals containing titanium	Disthene	Amphibole	Epidote group	Baryta
Mantle clay loam	150—160	1,20	70	26,5	1,5	2	Trace	25,5	5	5	Trace	1	—	0,25	6,5	0,25	25,5	31	—
Morainic clay loam	320—330	1,97	55	40	1	3	1	28,0	4,5	2	0,5	11	0,5	Trace	6,5	Trace	18	39	Trace

Note: Comma represents decimal point.

The foregoing data agree with those in the terature (4, 6, 7, 8, 9, 11) and point to the imilarity in the chemical and mineralogical omposition of mantle clay loam and the underying moraine. This allows us to agree with ne opinion that the initial material of the antle clay loam was the moraine.

The problem of the formation of mantle lay loam from the moraine is debatable. We ill not dwell on the various viewpoints on this roblem, but will only examine certain analytial data relating to it. First, let us examine ne data of electron-microscope and structural -ray analyses of finely disperse fractions[2] emoved from the soil over the mantle clay oams of the Vologda Region and the Komi SSR.[3]

Four samples were analyzed, three from ne A_2 (15-20 cm), the B (70-75 cm), and the (145-150 cm) horizons in Profile 34 (Vologda blast'), and the fourth from the C (150-160 m) horizon in Profile 270.

V. A. Appolonova's conclusions mention that ll the foregoing samples are basically similar their mineralogical composition. A preominant number of particles has the form f small, thin, semi-transparent scale-plates ith an uneven outline, and pertains to clay inerals of the hydromica type. Some kaolinite included. Consequently, the mantle deosits of the Vologda Oblast' and of the Komi SSR, as well as the soils developed on them, re characterized by an identical mineralogial composition, which must indicate a genetic elationship between these deposits.

In interpreting the results of mineralogial analysis of finely dispersed fractions, a reat importance is played by their total chemial composition. According to the results of ir total chemical analysis of colloidal fracons ($<0.2\mu$ in diameter) removed from the ree samples of mantle clay loam (from the ologda Oblast' and the Komi ASSR) and om the various genetic horizons of podzolic oils developed on these deposits (Table 5), e molecular ratio between $SiO_2:R_2O_3$ in these amples is close to 2, i. e., it is smaller an for "pure illites," but our $SiO_2:Al_2O_3$ atio almost fully agrees with that mentioned the work of Grim, Bradley, and Brown) for illites. Consequently, the colloidal action of mantle clay loams is characterized a larger divergence between the $SiO_2:R_2O_3$ d $SiO_2:Al_2O_3$ ratios than illite, which is tributable to a much higher iron oxide content our samples. It must be noted that the relts of the total chemical analysis of the lloidal fraction from mantle clay loam and om soils overlying it agree well with similar ta for the colloids of mantle clay loam from e Moscow Oblast', given in the work of erigina (2). The only difference is that the tter contain somewhat more silica, and that the $SiO_2:R_2O_3$ is noticeably higher than in illites. Thus, colloids from mantle clay loams are far from being identical with illite as far as their chemical composition is concerned.

It must be emphasized that the total chemical composition of colloids from the podzolic horizon of soils on the mantle clay loam of the Vologda Oblast' is characterized by a lower silica content, as a result of which the molecular ratio $SiO_2:R_2O_3$ is decreased. This indicates that under the given soil formation, the composition of mantle clay loam (parent material) changes.

What influence does mantle clay loam have on soils forming on it? This material may be classified as quartz-clay on the basis of the results of mineralogical and chemical analyses, since the clay matter and the quartz particles are the major components which determine almost all the important properties of this material. The foregoing mineral composition of mantle clay loam must promote the podzol formation process in soils developing on this material (under corresponding geographical conditions). This may be explained first of all by the fact that the clay minerals in it are subject to decomposition, while the more stable components, such as hydromica and kaolinite, have much less exchange capacity. In the second place, the pronounced quartz composition of the predominating silt fractions causes a considerable shift in the composition and properties of the soil mass during the decomposition and removal of clay particles. Consequently, the chemical composition and the physicochemical properties of soils may change rapidly during the development of the soil-formation process on mantle deposits.

To substantiate the foregoing let us examine certain analytical data for soils on mantle clay loams and moraines. Soil Profiles 34 and 188 are typical for the watersheds of elevations in the Vologda Oblast'. They develop on more or less thick, similar mantle clay loams under moss-spruce forests. The soil in Profile 34 is coarsely humic, strongly podzolic and gleyey, while that in Profile 188 is coarsely humic and strongly podzolic.

Both soils are very similar in particle-size distribution. They have pronounced podzolic horizons with a low amount of clay (Table 6). The results of acidity determinations (pH in KCl) indicate a decrease in acidity in the A_2 horizon as compared with the underlying A_2B horizon, which is characteristic for soils on mantle clay loams. The podzolic horizon stands out sharply by its content in exchangeable cations.

Thus, the foregoing soils belong to strongly podzolic soils, judging by the thickness of their podzolic horizon, its sharp differentiation from the accumulative horizon, the sharp decrease in the content of adsorbed cations and clay in it as compared to the deposit, and by the decrease in the acidity of the podzolic horizon as compared to the high acidity of the A_0 and A_2B horizons. The results of total chemical analysis (Table 6 gives only data on the total content of SiO_2 and CaO) do not contradict this. Both soils have the same SiO_2 content (80%) in

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[2] The analyses were made by V. A. Appolonov at the lurgy Institute.

[3] Samples of typical, strongly podzolic soil from Komi ASSR (Profiles 270-273) were sent to us I. V. Zaboyeva at our request.

Table 5

Results of the total chemical analysis of colloids

Profile No. and its location	Depth, cm	In percent of ignited mineral mass									
		SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	P_2O_5	MnO	CaO	MgO	mol $\frac{SiO_2}{Al_2O_3}$	mol $\frac{SiO_2}{R_2O_3}$
34. Vologda Oblast'	15—20	48,31	35,73	27,82	7,48	0,43	0,053	0,14	3,26	2,94	2,49
	45—50	49,66	35,90	26,55	9,12	0,23	0,048	0,15	4,13	3,15	2,58
	70—75	50,20	37,03	25,70	11,03	0,30	0,056	0,10	3,07	3,31	2,59
	145—150	50,44	36,22	25,40	10,44	0,38	0,045	0,18	3,26	3,32	2,63
35. Vologda Oblast'	10—15	43,1	37,6	25,8	11,15	0,65	0,075	0,18	2,80	2,8	2,20
	25—30	45,3	38,0	25,6	12,0	0,40	0,068	0,15	3,20	3,0	2,29
	65—70	48,9	38,6	26,4	11,7	0,43	0,063	0,16	3,53	3,14	2,43
	140—145	49,3	38,1	25,8	11,6	0,58	0,065	0,15	3,60	3,24	2,50
270. Komi ASSR	75—85	50,05	38,80	25,25	13,2	0,35	0,072	0,05	3,91	3,38	2,51
	145—150	50,83	38,74	25,35	11,9	0,46	0,054	0,07	4,40	3,41	2,60

Note: Comma represents decimal point.

the podzolic horizon and have no accumulation of calcium and other ash elements.

Soils in areas with mantle clay loams noticeably differ from soils on morainic deposits by their greater homogeneity. This was mentioned by authors who investigated the soils of the Vologda Oblast' (1, 9), and also by Ufimtseva (13). The works of Zavalishin (4), and Skrynnikova (11) contain data on the characteristics of soils and soil formation on the mantle clay loams of the Moscow Oblast'.

Soils on morainic deposits are characterized by Profiles 56 and 61 made in the Totem district on an elevation in an interfluve, i. e., approximately under the same conditions as soil profiles on mantle clay loams. The soil in Profiles 56 is coarsely humic, dark-colored, gleyed at the surface, weakly podzolic from a spruce-birch forest. The soil in Profile 61 is sod-strongly podzolic from a cut spruce-birch forest with occasional grasses. These profiles differ greatly in particle-size distribution. In Profile 56, the gravelly sandy clay loam is underlain by finer boulder clay loam, while in Profile 61 a different grain size of sand is underlain by medium boulder clay loam. The clay content increases considerably in the upper horizons of both profiles (Table 6). The podzolic horizon in Profile 61 does not stand out by its clay content; podzol formation probably embraces a thick layer here. Profile 56 has a high clay content (9.43%) in the podzolic horizon.

The soils examined differ greatly in other ways. The A_1 horizon under a semi-humified litter in Profile 56 contains about 12% humus which is almost saturated with bases. The amount of adsorbed bases in this horizon, in contrast to soils of mantle clay loams, exceeds their content in the underlying material. Nothing can be said about the degree of removal of bases from the podzolic horizon, but the saturation of this horizon with bases is greater (about 6 meq with very low acidity) than in the podzolic horizons of soils on mantle clay loams. Thus, the biogenic accumulation of calcium is undoubtedly very pronounced here, which is associated with the proximity of the underlying carbonate material.

The results of total chemical analysis show the consequences of the prolonged accumulation of the most important ash elements in the same soil even more clearly. We do not give the complete data, but the total content of CaO shows how pronounced the accumulative horizon is. As far as the podzolization of the soil is concerned, these data indicate the podzolization of the 20-25 cm layer and, probably, the 35-40 cm layer. All these facts confirm that this soil is dark-colored, weakly podzolic, enriched with not fully humified organic material, and under the influence of periodic excessive wetting by hard soil- and groundwaters.

Analyses of Profile 61 show an entirely different picture. The entire soil here is noticeably acid and contains a small amount of adsorbed bases. The accumulative humus horizon breaks sharply, while the lower-lying, podzolized portion of the soil shows signs of a slight removal of humic acids without being fixed in the B horizon. Total chemical analysis clearly shows evidence of podzol formation in this profile, while the secondary accumulation of calcium is weakly expressed.

Thus, the soils on morainic deposits and

Table 6

Analytical soil indices

Profile No.	Depth, cm	Genetic horizon	pH KCl	Humus (according to Tyurin), %	Adsorbed Ca^{++} Mg^{++} meq (according to Gedroyts)	Content of particles of given diameter, mm		Total content in % of ignited mineral mass	
						<0,01	<0,001	SiO_2	CaO
On mantle clay loams									
34	0—4	A_0	3,47	57,5[a]	19,89	—	—	75,82	1,83
	4—9	A_0A_1	4,42	15,7	7,95	—	—	76,67	1,96
	15—20	A_2	3,97	0,50	4,53	22,07	8,06	79,87	1,09
	30—35	A_2B	3,80	0,38	13,62	43,41	23,89	73,10	1,00
	45—50	A_2B	3,85	0,36	20,13	51,28	35,34	71,71	1,06
	70—75	B	4,35	0,25	22,11	48,48	34,16	73,06	1,28
	120—125	B	5,63	—	26,90	44,19	25,97	74,16	1,46
	145—150	BC	6,28	—	—	45,19	26,81	71,45	3,05
188	0—5	A_0	3,85	18,9	15,22	—	—	78,99	1,16
	12—17	A_2	4,11	0,24	2,99	30,36	7,24	80,00	1,11
	28—33	A_2B	4,06	0,21	13,74	50,06	32,58	72,24	0,98
	65—70	B	4,62	0,17	19,17	47,48	32,17	73,33	1,26
	113—118	C	5,70	—	20,30	41,42	24,96	73,79	1,46
On morainic deposits									
56	0—2	A_0	4,90	38,26[a]	41,24	—	—	72,65	2,54
	5—10	A_0A_1	4,40	11,93	28,61	44,81	27,92	74,81	1,71
	20—25	A_2BC_1	4,40	1,28	5,77	26,95	9,49	80,93	1,46
	35—40	A_2BC_2	4,10	0,41	14,70	37,37	22,56	75,65	1,43
	60—70	C_2	4,60	0,36	19,14	45,66	29,89	73,61	1,52
61	0—8	A_0A_1	3,60	4,91	4,90	27,47	16,65	88,19	1,12
	10—15	A_2	4,00	0,50	1,29	6,73	3,49	89,93	1,04
	15—20	A_2B	4,35	0,50	1,35	7,39	4,12	88,97	1,04
	33—40	A_2BC_1	4,50	0,26	1,55	13,33	3,92	85,95	1,14
	45—50	BC_1	4,00	0,11	3,53	16,30	5,80	83,76	1,11
	75—80	C_2	3,80	—	—	30,39	21.61	81,40	1,13

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[a] Ignition loss

Note: Comma represents decimal point.

heir derivatives in the Volgda Oblast' differ
reatly from soils on mantle clay loams, which
s in complete agreement with data found in
he literature. Soils on morainic deposits
re much more varied as far as the degree
f development of podzol formation is con-
erned, but this process is much less pro-
ounced, even in their most strongly podzolic
arieties than it is in soils on mantle clay
oams. In addition to this, soils on morainic
eposits are distinguished by a greater ampli-
ude of variations in the nature and degree of
evelopment of accumulative horizons; among
hese are dark-colored, humic-podzolic and
ley soils with almost saturated humus hori-
ons. All this is determined by the properties
f the parent materials, such as the high car-
onate content of the moraine and the two-
ayer structure of the soil-forming layer.

Thus, the composition and properties of parent material have a great influence on soils; essentially differing soils form on various parent materials under similar physiographic conditions. The role of deposits as a soil-forming factor must vary during various stages of soil development. It may be assumed that in the first stages of soil formation on mantle deposits the properties of these deposits played the primary role in the system of other soil-formation factors. Later, the role of vegetation assumed more and more importance, its diversity determining essentially the differences between soils on mantle deposits.

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HARACTERIZATION OF THE MOISTURE PROPERTIES, GAS PHASE, ND THE MICROFLORA OF FLOOD-PLAIN SOILS

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Flood-plain soils are usually considered as ils with a high moisture content, that is, rdromorphous. Even if it is generally true, on oser examination of the moisture of various ood-plain soils one finds that their degree of rdromorphism is far from being similar. More an that, some river flood-plain soils have arply differing moisture regimes, starting om typically bog soils and ending with soils eriodically, or even constantly, deficient in oisture during the greatest part of the growing riod (e.g., sod soils of steppe-like meadows the crests of river-side ridges).

There is a vast amount of material in the erature which characterizes the moisture gime of various flood-plain soils, but there is most no systematization and classification of oisture regime types. Only in recent years s this problem begun to attract attention (2, 3, 6, 10. 12). However, the most important dif- rences in the properties of flood-plain soils d in the nature of their vegetation and fauna e associated with the various types of mois- re and air regime. Because of the work of obotanists the adaptation of various plant as- ciations to flood-plain soils of various de- ees of moisture is fairly well known. There very little material in this direction on soil una and even less material characterizing the icroflora of flood-plain soils and the composi- on of their gas phase in relation to various oisture regimes (15). This situation induces to present the observations made by us in the ood plain of the Klyaz'ma River in Kovrov yon, Vladimir Oblast', in 1956-1958.

We investigated the profile across the Klyaz'- a River valley and selected test areas embrac- g the major soil groups of the Klyaz'ma flood ain and of the main bank. In addition to study- g chemical properties and the composition of getation and soil fauna, we investigated the ld moisture capacity of soils in these areas ly and September 1956, May and July 1957, d July 1958), the composition of soil air ly 1957 and 1958), the group composition of croorganisms (July 1958), and the active croflora of soils (July and August 1956).[1]

These investigations cannot be considered as standard, since the limited number of observation periods did not allow us to determine the dynamics of the phenomena. However, these observations, having been made simultaneously in all areas and during several periods, allowed us to determine differences in moisture and in the composition of the gas phase, as well as certain microbiological characteristics of the major soil groups in the Klyaz'ma flood plain during the summer months.

In order to save space we will not give a description of the soils investigated, nor their characteristics and properties, since they were described in earlier publications (7, 8), using the same numbering for the areas. The flood-plain soils are designated according to the classification proposed by one of us (6).

The data on hydrophysical properties presented in Table 1 show that the finer is the texture of the soils and the more humus they contain, the higher are their maximum hygroscopic moisture and maximum molecular water capacity, i.e., the higher is the amount of bound water. It must be noted that these values increase in the gleyey horizons of all meadow, meadow-bog and peat gleyey soils, forming a second maximum in the lower part of the profile of these soils.

Porosity varies regularly with the groups of flood-plain soils. It increases at the transition from river-side sod soils to meadow soils of the central flood plain and then decreases in terrace-side, water-logged soils. Such variations in porosity are determined by variations in the texture and aggregation of the foregoing soils. Well-aggregated clayey meadow soils of the central flood plain have the highest porosity, River-side sod soils have a lesser porosity, while sandy podzolic soils of the main bank have the lowest porosity.

What is the moisture of these soils and their water-air relationship. We can judge this from the data given in Tables 2 and 3 and from Figures 1-5. Let us note that the weather conditions during the periods of observations varied greatly. The driest and warmest periods were the spring and summer of 1957 and the wettest, the summer and early autumn of 1956, while the summer of 1958 was intermediate between the two.

Since we cannot include in this article all the

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[1] Certain conclusions from the observations on the ive microflora were included in this article with permission of Yu.G. Gel'tser, who made them.

Table 1

Hydrophysical properties of soils in the Klyaz'ma valley

Experimental Area Number	Soil	Horizon, depth, cm	Humus, %	<0.01 mm diameter particles, %	Particle density	Bulk density, g/cm³	Maximum hygroscopic moisture	Maximum molecular water capacity	Film water	Total porosity, %	Volume of the solid phase, %
							in percent				
7	Sod-podzolic sandy, main bank	Ad 0—3	3,61	Not det'd.			Not det'd.				
		A_1 3—8	0,95	7,5	2,65	1,52	0,74	4,91	4,17	42,4	57,6
		A_1 22—27	0,09	5,8	2,64	1,52	0,60	3,62	3,02	42,5	57,5
		A_2 38—43	0,04	Not det'd.	2,65	1,68	0,31	3,40	3,10	35,1	64,9
		B 85—92		19,9	2,75	1,80	1,97	10,29	8,32	34,7	65,3
		C 160—170		24,0	2,69	1,83	2,67	9,12	6,45	32,0	68,0
2	Sod meadow coarse clay loam, river-side flood plain	Ad 0—4	4,02	Not det'd.	2,58	1,00	5,22	17,15	11,93	62,9	37,1
		A_1 6—11	2,58	22,2	2,62	1,33	4,55	15,05	10,50	49,3	50,7
		B_1 16—21	1,46	16,4	2,65	1,34	3,00	13,65	10,65	49,3	50,7
		B_2 27—37	0,85	12,9	2,65	1,31	2,34	12,06	9,62	50,8	49,2
		C 70—80		8,3	2,64	1,42	1,73	8,28	6,55	46,3	53,7
4	Sod-meadow clay loam, ridged central flood plain	Ad 0—5	Not det'd.	52,6	2,50	0,67	8,20	26,38	18,18	73,2	26,8
		A_1 10—15	"	47,0	2,45	1,16	6,89	19,09	12,20	52,6	47,4
		$A_{bndry.}$ 25—30	"	45,7	2,58	1,05	6,80	18,71	11,91	59,4	40,6
		B 45—50	"	34,7	2,64	1,27	4,95	14,80	9,85	51,8	48,2
		C_1 60—70	"	10,6	2,64	1,38	2,69	4,91	2,22	47,7	52,3
		C_2 100—110	"	Not det'd.	2,67	1,55	8,93	13,07	5,84	42,2	57,8
1	Meadow clay loam, flat, central flood plain	A 0—5	12,41	Not det'd.	2,36	0,45	12,9	35,62	22,72	80,8	19,2
		A_1 8—13	7,56	60,7	2,59	0,84	13,0	32,12	19,12	67,5	32,5
		A_1 19—24	5,50	37,2	2,80	1,09	12,0	25,71	13,71	61,0	39,0
		B_1 40—45	1,98	38,8	2,87	1,26	10,2	21,74	11,54	56,0	44,0
		B 85—90	0,81	55,1	2,74	1,53	10,2	23,70	13,50	44,2	55,8
		C 125—130		6,2			1,05	5,39	4,24	44,2	55,8
5	Meadow-bog clay, terrace side	Ad 0—5	10,04	Not det'd.	2,37	0,56	4,89	18,51	13,62	76,6	23,4
		A 8—13	8,61	49,5	2,50	0,96	7,53	25,92	18,39	61,5	38,5
		B_1 22—32	0,55	31,2	2,68	1,30	5,45	15,04	9,59	51,5	48,5
		B 42—52	—	37,5	2,71	1,50	7,58	16,59	9,01	44,6	55,4
		C 90—100	—	2,2	Not det'd.		0,46	1,78	1,32		
	Water-logged peat-gleyey	A_T 0—10	Peat	Not det'd.			10,51	37,70	27,19	Not det'd.	
		B,G 60—70	13,25	"			8,24	20,60	12,36	"	
		B G105—115		"			13,57	44,14	30,57	"	

Remarks: 1. Maximum molecular moisture capacity was determined by the Lebedev method, as modified by Vasil'yeva (1). 2. Data on the particle density, maximum hygroscopic moisture and maximum molecular moisture capacity are averages from 3 measure-

Table 2

Relationship between soil pores containing water and air in percentage of volume

Exper. Area No.	Soil	Depth, cm	Pore volume occupied by water (primarily capillary)[a]					Total pore volume occupied by water (field moisture)					Pore volume occupied by air				
			July 1956	Sept. 1956	May 1957	July 1957	July 1958	July 1956	Sept. 1956	May 1957	July 1957	July 1958	July 1956	Sept. 1956	May 1957	July 1957	July 1958
7	Sod-podzolic	3—8	10,5	9,18	22,3	9,1	3,7	17,5	16,2	29,3	16,1	10,7	24,8	26,2	13,1	26,2	31,6
		8—13	Not det'd.		4,2	4,0	2,0	Not det'd.		11,2	11,0	9,3	Not det'd.		31,2	31,3	33,3
		22—27	6,5	10,1	7,6	4,4	6,1	11,7	15,3	12,8	9,6	11,3	30,8	27,2	29,7	32,9	31,2
		38—43	7,6	11,1	6,6	2,3	4,3	13,1	16,6	12,1	7,8	9,8	21,9	18,4	22,9	27,2	25,2
		55—65	Not det'd.		17,7	8,1	14,5	Not det'd.		29,5	19,9	26,3	Not det'd.		5,6	15,1	7,8
		70—75	5,3	13,4	14,4	4,6	13,8	20,5	28,7	29,7	19,9	29,1	14,1	5,9	5,0	14,7	5,5
		85—92	Not det'd.		10,5	1,7	15,6	Not det'd.		28,5	19,7	33,6	Not det'd.		6,1	14,9	1,0
		97—102	1,7	10,9	0,3	7,5	14,5	19,7	28,9	18,3	25,5	32,4	12,0	2,9	13,4	6,2	None
		115—120	Not det'd.		2,7	4,4	18,6	Not det'd.		19,0	20,7	32,4	Not det'd.		12,7	11,0	"
		160—170	3,4	6,3	Not det'd.			18,5	21,4				13,5	10,6			
2	Sod	0—5	18,0	20,2	None	3,6	7,9	33,4	35,6	10,8	19,0	23,3	29,5	27,3	52,1	53,9	39,6
		6—11	6,5	14,4	"	1,1	8,6	24,5	32,4	13,0	19,1	26,6	24,8	16,9	36,3	30,2	22,7
		16—21	4,8	8,3	"	None		21,8	25,3	14,0	11,4	14,2	27,5	24,0	35,3	37,9	35,1
		27—37	None	4,3	"	"		9,4	19,1	12,7	12,5	10,5	41,4	41,7	38,1	38,3	40,3
		50—60	Not det'd.		"	"		Not det'd.		13,8	11,9	8,8	Not det'd.		34,7	36,7	39,8
		100—110	3,9	7,1	9,7	3,4	1,97	14,8	18,0	20,6	14,3	12,9	31,5	28,3	25,7	32,0	33,4
		120—130	Not det'd.		6,9	3,4	2,8	Not det'd.		17,8	14,3	13,7	Not det'd.		28,5	32,0	32,6
		140—150	"		Not det'd.	3,2	None	"		Not det'd.	14,1	Not det'd.	"		Not detd.	32,2	Not det'd.
4	Sod-meadow	0—5	16,6	16,5	"	3,8	13,1	32,4	32,3	Not det'd	19,6	28,9	40,8	40,9	Not det'd	53,6	44,3
		10—15	14,0	17,5	"	3,5	10,2	33,5	37,0	"	23,0	29,7	19,1	15,6	"	29,6	22,9
		25—30	14,7	16,9	"	11,8	13,0	32,0	32,2	"	29,1	30,3	27,4	27,2	"	30,3	29,1
		35—45	18,5	20,9	"	Not det'd.		35,4	37,8	"	Not det'd.		20,2	17,8	"	Not det'd.	
		45—50	Not det'd.		"	12,9	8,6	Not det'd.		"	29,6	25,3	Not det'd.		"	22,2	26,5
		60—70	15,6	13,1	"	13,2	9,8	21,1	18,6	"	18,7	15,3	26,6	29,1	"	29,0	32,4
		80—90	Not det'd.		"	4,5	1,5	Not det'd.		"	13,5	10,5	Not det'd.		"	28,7	31,7
		100—110	"		"	2,3	3,2	"		"	11,3	12,2	"		"	30,9	30,0
		120—130	16,6	12,8	"	11,6	4,7	25,6	21,8	"	20,6	13,7	16,6	20,4	"	21,6	28,5
		145—150	—	—	—	12,5	11,6	—		"	21,5	20,6	—	—	"	20,7	21,6

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[a] The amount of free water was calculated from the difference between field moisture capacity and the amount of bound water, consisting of maximum hygroscopic and film water.

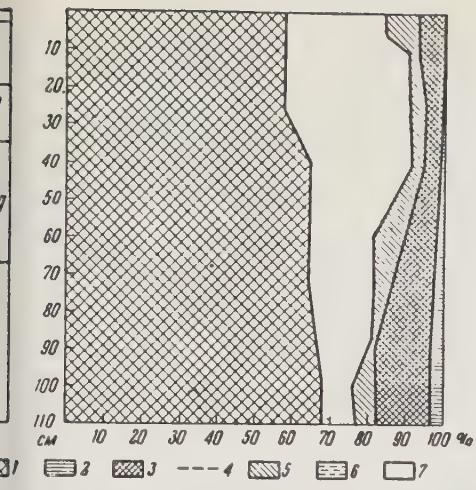
Note: Comma represents decimal point.

Table 3

Relationship between soil pores occupied by water and air in percentage of volume

Exper. Area No.	Soil	Depth, cm	Pore volume occupied by free water (primarily capillary)						Total pore volume occupied by water (field moisture)				Pore volume occupied by air				
			July 1956	Sept. 1956	May 1957	July 1957	July 1958	July 1956	Sept. 1956	May 1957	July 1957	July 1957	July 1956	Sept. 1956	May 1957	July 1957	July 1958
1	Meadow	0—5	13,7	26,3	28,5	12,7	11,0	27,8	40,4	42,6	26,8	25,1	53,0	40,4	38,2	54,0	55,7
		8—13	17,2	29,9	34,3	23,5	18,4	40,5	53,2	57,6	46,8	41,7	27,0	14,3	9,9	20,7	25,8
		19—24	12,2	20,1	21,0	10,3	7,7	35,9	43,8	44,7	34,0	31,4	25,1	17,2	16,3	27,0	29,6
		40—45	12,7	10,7	20,5	9,9	5,8	35,8	33,8	43,6	33,0	28,9	20,2	22,2	12,2	23,0	27,1
		60—65	Not det'd.		16,7	8,8	4,3	Not det'd.		43,8	35,9	31,4	Not det'd.		6,3	14,2	18,7
		85—90	13,4	3,8	11,0	8,6	9,5	44,3	34,9	42,3	39,7	40,5	water	9,3	1,9	4,5	3,7
5	Meadow-bog	0—5	50,6	34,1	46,2	29,0	32,1	60,0	43,6	55,7	38,5	41,6	16,6	33,0	20,9	48,1	35,0
		8—13	32,3	21,1	34,2	11,7	32,8	49,8	38,6	51,7	29,2	50,3	11,7	22,9	9,8	42,3	11,2
		22—32	10,6	water	13,5	2,3	8,8	27,8	water	30,7	19,5	27,0	23,7	None	20,8	32,0	24,5
		42—52	20,6	"	16,0	12,8	2,0	41,1	"	37,1	33,9	23,1	3,5	"	7,5	10,7	21,5
		70—80	water	"	water	20,6	20,7	water	"	water	41,7	41,8	None	"	None	2,9	2,8
		90—100	"	"	"	23,7	23,2	"	"	"	44,8	44,3	"	"	"	None	

Note: Comma represents decimal point.

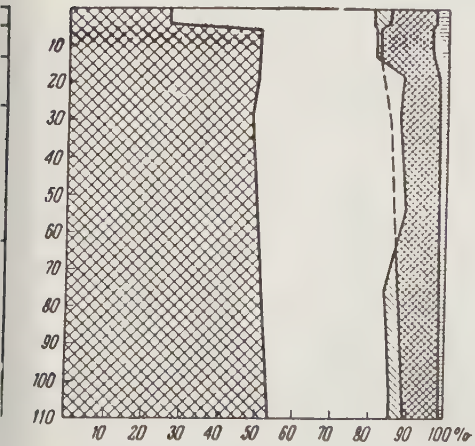


1 - Differential porosity of sod-podzolic soil, July 1957.

olume of solid phase; 2 - pore volume occupied
ximum hygroscopic water; 3 - pore volume oc-
d by film water; 4 - limit of porosity corres-
ng to film water in sod soil; 5 - pore volume
ied by free water (primarily capillary); 6 -
d water; 7 - aeration pores.

on differential porosity at various periods
bservation, we will limit ourselves in
senting data on pores occupied by total
er, free water, and aeration pores.

irst, let us examine the podzolic soil of the
n bank. In spite of the low total porosity,
range of aeration pores in the upper hori-
s of this soil is not too narrow because of
low porosity owing to bound water, i.e., the
of maximum hygroscopic and film water.
entirely different picture is found in the
er part of the soil profile (B and B/C hori-
s), where total porosity decreases even
e and at the same time the porosity from
d water greatly increases; the volume of



2 - Differential porosity of river-side sod
, July 1957 (symbols same as in Figure 1).

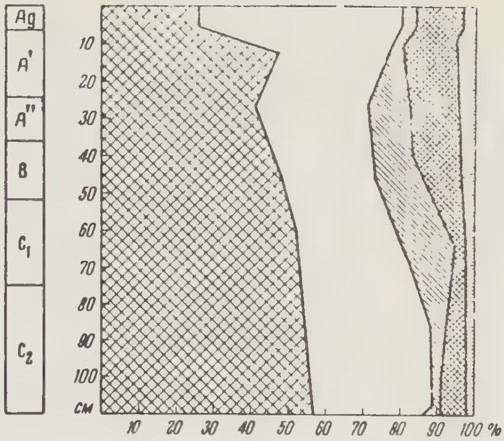


Fig. 3 - Differential porosity of sod-meadow soil in the central flood plain, July 1957 (symbols same as in Figure 1).

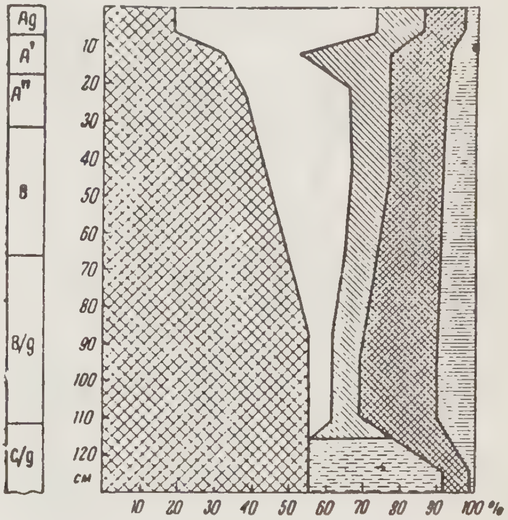


Fig. 4 - Differential porosity of meadow soil in the central flood plain, July 1957 (symbols same as in Figure 1).

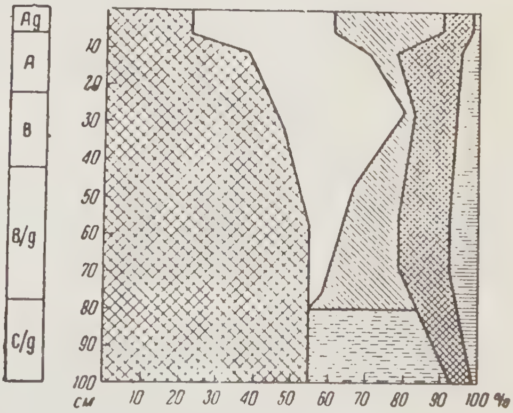


Fig. 5 - Differential porosity of meadow-bog terrace-side soil, July 1957.

Table 6

Results of microbiological analysis of soils in the Klyaz'ma River flood plain, July 10-12, 1958

Experimental Area No.	Soil	Horizon	Depth, cm	Bacteria in 1000/1 g of soil					Actinomyces	Fungi	Sulfate-reducing bacteria	Decomposition of cellulose	
				Meat-peptone-Agar (MPA)	MPA+ must	%-spore-formers	medium		in 1000/1 g of soil			process intensity	decomp. type
							Ashby	Chapek					
7	Sod-podzolic	A_1	3—13	88	54	61	71	106	36	5,2	—	+++	BFA
		A_1	20—30	28	23	82	44	87	15	1,0	—	±	A
		A_2	35—45	34	20	58	32	96	14	1,4	—	±	A
		B/C	50—60	9	5	55	9	10	3	0,7	—	—	—
	Sod	A_1	4—14	1812	102	5	3176	1900	182	1,6	—	+++	B
		B	14—24	868	352	4	1040	1036	373	2,4	—	+++	B
		B/C	27—37	48	22	46	336	518	456	4,0	—	++	BFA
		C	45—55	65	68	105	360	376	396	2,5	—	++	BFA
1	Meadow	A_1	7—15	448	70	15	556	243	144	2,0	+++	++	BF
		A	18—28	288	6	2	244	414	12	1,0	—	++	BFA
		B	40—50	49	26	53	32	152	3	1,2	—	+	A
		B_2	60—65	48	9	18	57	112	9	0,52	—	+	A
6	Water-logged peat-gleyey	A_1	0—10	532	78	14	534	1026	7	1,2	+++	+++	BA
		A_1	10—20	110	21	19	236	350	1	0,5	++	+	A
		G	44—49	5	4	80	956	688	0	—	+	±	A
		G_1	53—38	18	3	16	46	1072	0	—	++	±	A

Remarks: 1. Actinomyces were determined in Chapek's medium with chalk, fungi, in acidified must-agar; sulfate-reducing bacteria, in Baars' medium; the decomposition of cellulose was studied on soil slides and in the agarized medium of Hetchinson with filter paper. 2. The letters ABF designate the type of cellulose decomposition: B — bacterial, F — fungi, A —actinomyces; the signs +and - designate the degree of the process.

Note: Comma represents decimal point.

Table 4

Composition of soil air, in %, at 760 mm pressure and a temperature of 0°C. July 1957

Expt'l. Area No.	Soil	Depth at which air samples were taken cm	CO_2	O_2	N_2 with a gas residue
7	Sod-podzolic	10—15	0,29	20,78	78,98
		25—30	0,37	20,74	78,89
		45—55	0,39	20,64	78,97
2	Sod	10—15	1,01	20,11	78,88
		20—25	1,34	19,89	78,77
		50—55	1,52	19,65	78,83
4	Sod-meadow	10—15	0,52	20,66	78,82
		20—25	0,60	20,50	78,90
		50—55	0,66	Not det'd.	
1	Meadow	10—15	0,47	20,37	79,16
		25—30	1,09	20,32	78,49
		45—50	1,13	20,29	78,43

tion pores decreases here to 14%. This ıs that a small increase of moisture in the st part of the soil profile on top of bound r would lead to the filling of most of the s with water, the gas exchange in the soil d be disturbed, and anaerobic conditions d be established. This is exactly what oc- in the spring and autumn months and also ened in the rainy July of 1958. Only in the ner months are conditions favorable in the tureless soil for gas exchange with at- heric air.

s was to be expected, moisture differed greatly in the various flood-plain soil groups. The most pronounced feature of river-side sod soils (area No. 2) is the presence in their profile of a dry horizon at a depth of 20-70 cm, where soil moisture sometimes drops to the wilting point (Table 2, Fig. 2). This horizon points to the break of sod soils from the capillary fringe of ground waters and, consequently, to the atmospheric type for their water during the summer months. The dependence of the moisture of sod soils (which are very permeable and have a low water capacity) on atmospheric precipitation, results in an unstable water supply in these river-side soils. In wet years sod

Table 5

Composition of soil air, in %, at 760 mm pressure and a temperature of 0°C. July 1957

xpt'l. Area No.	Soil	Depth at which air samples were taken cm	CO_2	O_2	H_2	CO	CH_4 and other hydrocarbons	N_2 with rare-earth gases
5	Meadow-bog	10—15	1,66	20,13	0,12	0,07	0,49	77,52
		25—35	3,39	19,39	0,15	0,17	1,43	75,80
		45—55	3,91	19,33	Not det'd.	0,30	1,99	75,47
6	Peat-gleyey	10—15	6,31	14,50	0,14	0,03	0,58	78,39
		30—35	15,47	1,03	0,03	0,05	2,39	80,98

Remarks: 1. Soil air was analyzed in a modified VTI-1 gas analyzer. Samples of air were en three times from each horizon; the tables give average data. 2. The results of the alysis of 1958 samples are not given since they are not sufficiently accurate, having been ot in the ampoules for a long time. The order of the numbers and the relation between the composition of air in the various soil groups in 1958 were the same as in 1957.

Note: Comma represents decimal point.

soils give high grass yields, while in dry years the yields drop considerably.

The grass of the foregoing sod soil is represented by fescue-timothy-mixed grass associations. The vegetation of sod soils on the highest ridges is distinguished by steppe grasses where such as Festuca ovina and Koeleria gracilis predominate.

In spite of the rather small total porosity of sod soils, their effective porosity is rather high, since bound water occupies less than one fourth of the total porosity. The high effective porosity of sod soils creates favorable conditions for air penetration and gas exchange.

Sod-meadow soils of the ridged central flood plain are characterized by a high effective porosity (Table 2). Their moisture properties are characterized by the fact that in addition to being fed by atmospheric water they are also fed by ground water, even though not constantly.

As may be seen from Table 2, pores containing water occupy not more than 50%-70% of the total porosity in sod-meadow soils, which indicates good aeration with a sufficient moisture supply.

In contrast to sod-meadow soils, typical meadow soils of the flat portion of the central flood plain have a constant supply of ground water. Ground water rarely drops here deeper than 110-120 cm.

Attention is drawn to the large amount of bound water in meadow soils, which is due to the fine texture, and the high content of humus and organo-mineral colloids in these soils. In spite of the high moisture of meadow soils, their humus horizons are sufficiently aerated. This is attributable to the high aggregation of the humus horizons of these soils. Lower, in the structureless, compact, and sticky B/G horizon, the percent of aeration pores is very low (Table 3, Fig. 4), and the horizon lacks air permeability, which leads to the development of anaerobic processes in it.

During the growing period ground water in meadow soils is generally located at the critical level, at which the upper part of the soil profile still retains favorable moisture and aeration c ditions, while at a depth of 60-70 cm a deficier in aeration begins to be felt as a result of exce ive moisture. At times deficient aeration is fe in the higher horizons (40-45 cm in May 1957).

Meadow soil vegetation is represented by a moist hair-grass-foxtail grass-mixed grass meadow.

If the moisture of meadow soils is generally favorable and a deficiency in aeration occurs i them only at certain moments during the growi period, excess moisture and an air deficiency characteristic of the air and water regime of terrace-side meadow-bog and bog soils.

As may be seen from data in Table 3, groun water in meadow-bog soils (area No. 5) drops below 0.5 m only during dry summer months. During these months aeration is adequate to a depth of 35-40 cm (Fig. 5). The rest of the time aeration porosity rarely reaches 30%-35% of the total soil porosity, even in the A_1 horizo

Deficient aeration in meadow-bog soils is caused not only by the high ground-water level but also by the high water retention capacity of the sod and the humus A_1 horizon which has a somewhat peaty character. Conformity with such an unfavorable water-air relationship is found in the vegetation of these soils. It is represented by a water-logged hair grass-sedg meadow with a small amount of mixed grasses

Terrace-side bog peat-gleyey soils have ev less favorable moisture properties (area No. 6 Sedges, water manna grass, canary grass, reed, and chee reed grass predominate in the vegetation of these soils, and among the mixed herbage, kingcup, true forget-me-not, etc., predominate.

Only once (early July 1956) during the 3 yea of observation did the ground-water level drop 80 cm, but it rose quickly after rains. Ordina the ground-water level in peat-gleyey soils fluctuates at a depth from 20 to 40 cm. These soils have a high water capacity and poor air permeability.

Data in Tables 4 and 5 clearly show how different is the composition of soil air in the vari

Table 7

Content of mobile organic material and dissolved gases in soil water, 1957

Experimental Area No.	Place where water samples were taken	Time when samples were taken	Oxidation, mg of oxygen per liter		O_2 mg/l	H_2S mg/l
			easily oxidized substances	total		
6	Peat-gleyey soil	May	50,0	159,0	0,44	13,80
		July	5,8	51,7	0,73	0,77
1	Meadow soil	May	0,8	3,9	7,70	2,5
		July	Trace	2,2	Not det'd.	None

Note: Comma represents decimal point.

roups of flood-plain soils. This is very atural, since the composition of soil air is etermined to a great extent by the intensity of ie gas exchange between the soil and the at-iosphere (5, 9, 14). The conditions of gas ex-hange in the various groups of flood-plain soils ary greatly, as may be seen from the foregoing aterial. But the composition of soil air also epends on the intensity of biochemical process-s in the soil and on the activity of roots (14, 15). i this respect, data in Table 6 are of interest. able 6 shows the results of the determination the intensity of the bacterial decomposition of ellulose and the reduction of sulfates in the oils studies, and also the results of calculations the number of microorganisms in them. hese data help the determination of the com-osition of the gas phase in the soils. In ex-mining the data of gas analysis, we first note e fact that the air of sod-podzolic soils con-ins less carbon dioxide than the air of flood-ain soils. This is understandable. Sod-odzolic soil differs from flood-plain soils by sharply reduced amount of microorganisms vith the exception of fungi), and the low in-nsity of cellulose decomposition, the latter king place only in the uppermost horizon. Ap-arently, under these conditions, very little arbon dioxide is produced in the gas phase of e soil, whereby intense gas exchange takes ace in the upper horizon.

The gas phase of river-side flood-plain sod oils is rather rich in carbon dioxide (>1%). his is associated with the high biological ctivity of sod soils, involving all types of icroorganisms—bacteria, actinomyces, and ngi.

Data in Table 6 clearly show that the decom-osition of cellulose is very intense in sod soils, hereby the bacterial type of decomposition edominates in the upper soil horizons, while mixed type of decomposition (bacteria, actino-yces, and fungi) occurs in the lower horizons. e increase in the number of spore-forming cteria and actinomyces with depth points to a omparative decrease in the same direction of obile forms of organic materials.

A study of culture glasses, placed in flood-ain soils in June and August of 1956, revealed at the population of active microflora was eatest in June in sod soils, while in August the tive microflora population of sod soils was ightly smaller than in meadow soils.

Judging by the aeration porosity, gas ex-ange in sod soils may be continuous during e entire growing period and penetrate to a nsiderable depth, except for very short peri-ls after heavy rains. The absence of sulfate-ducing bacteria throughout the soil profile is so evidence of its good aeration. It is inter-ting to note that we found the greatest number earth-worms in this soil, especially those longing to the species *Allolobophora caligin-a*, which prefer well-aerated soils (7). All is serves as evidence of the favorable condi-ons for aerobic decomposition of organic sub-ances in flood-plain sod soils.

The air of meadow soils of the central flood ain contains less carbon dioxide than that of d soil. This is associated with the smaller population of microorganisms in them as compared to sod soils, and a less intense decomposition of cellulose. In the upper horizons of meadow soils cellulose is decomposed by bacteria, fungi, and actinomyces, while in the lower horizons it is done exclusively by actinomyces.

Gas exchange in meadow soils is sometimes interrupted by temporary excessive wetting. However, these interruptions are so insignificant that they do not produce stable anaerobic conditions in the humus horizons. The latter are sufficiently aerated. This is confirmed by faunistic soil observations which show that the meadow soils studied are inhabited by a great number of various invertebrate soil animals (7).

The amount of carbon dioxide in the gas phase increases sharply in meadow-bog soils, and especially in bog peat-gleyey soils, where it reaches 15%, while the amount of oxygen drops to 1% (Table 5). The principal reason for this is the poor gas exchange between water-logged soils and the atmosphere. In meadow-bog soils gas exchange can occur only during the dry summer months and not deeper than to 40-50 cm. In peat-gleyey soils air is contained only in the upper peat horizon and only during short periods when the ground-water level drops. Even during such periods gas exchange is impared by the high moisture content of peat and sod.

In addition to the very high carbon dioxide content and the sharply decreased oxygen content, the gas phase of water-logged flood-plain soils contains a large amount of hydrocarbons, as well as noticeable amounts of hydrogen and carbon monoxide. There is a large amount of hydrogen sulfide, organic material (oxidizable), and a small amount of hydrogen in the ground water of peat-gleyey soil during the spring months (Table 7). All this is obviously determined by the anaerobic regime. This is also evidenced by the results of microbiological analysis. Almost the entire microflora of peat-gleyey soil is concentrated in the uppermost peat horizon with the exception of oligonitrophilic bacteria and saprophytes, which develop in the artificial medium of Chapek.

A study of culture glasses has shown considerable variations in the active microflora population of this horizon, depending on its moisture: a decrease in excess moisture as a result of the drop of the ground-water level in August 1957 (as compared to early June) was accompanied by an intensification in the activity of microflora.

As may be seen from Table 6, aerobic decomposition of cellulose is intense only in the upper horizon of peat-gleyey soil. This intensity rapidly decreases with soil depth, whereby the relative role of bacteria in it decreases and that of actinomyces increases. Sulfate-reducing bacteria are found throughout the profile of peat-gleyey soil, which is also an indication of the predominance of reducing processes in the soil under conditions of poor aeration. This is in agreement with the earlier-mentioned (7) paucity of invertebrate animals and their concentration at the surface of peat-gleyey soils.

In examining the results of microbiological analysis of the soils in the Klyaz'ma flood plain as a whole, we may note that as soils change from river-side sod soils to the meadow soils of the central flood plain and then to the water-logged terrace-side soils, the intensity of the decomposition of cellulose gradually decreases, whereby the relative role of bacteria in this process decreases, while that of fungi and actinomyces (especially the latter), increases. The decrease in sulfates increases regularly from the river side to the terrace side. As far as the results of the total count of microorganisms is concerned, the regularity is not as clear. These data definitely show that the greatest biological activity occurs in July in river-side sod soils. Whether it is retained during the entire growing period, we do not know.

There are reasons to think that the microorganism population of river-side sod soils and of the upper horizon of peat-gleyey terrace-side soils is subject to the greatest variations during the growing period and during climatically different years. To verify these assumptions, systematic and long-period observations are required. It is especially important to trace the dynamics of the number and activity of ecologically different groups of microorganisms.

All the data examined show how different is the degree of hydromorphism of the various flood-plain soil groups, and how closely the moisture properties of each of the soil groups are related with their gas phase, type of vegetation, microflora, and soil fauna.

Conclusions

1. The moisture of sod, meadow, and bog flood-plain soils differs during the summer (low water period):

a. Sod soils detached from the capillary fringe of ground water are therefore dependent on atmospheric precipitation for their moisture in summer. The coarse texture and low moisture content of sod soils result in their sufficient active porosity, and permit gas exchange with the atmosphere.

b. Meadow soils have a constant moisture because of ground water. In spite of the high moisture content of meadow soils, their humus horizons have a sufficient active porosity and satisfactory aeration because of their high aggregation.

c. Meadow-bog and especially water-logged peat-gleyey soils are characterized by excessive moisture because of the high ground-water level; their active porosity is insignificant and air exchange is possible only in the uppermost horizons and during short periods when the ground water drops.

2. The air of flood-plain soils contains more carbon dioxide than that of the sod-podzolic soils of the main bank. Among flood-plain soils the highest content of carbon dioxide with a very low content of oxygen was found in meadow-bog and water-logged terrace-side peat-gleyey soils, which is determined by their very poor aeration; the air of these soils also contains a high amount of hydrocarbon, while the ground water contains a large amount of hydrogen sulfite.

3. In spite of the sufficient aeration of meac and, especially, sod soils, their gas phase contains a high amount of carbon dioxide, which is attributable to the great intensity of biological processes in these flood-plain soil groups.

4. The results of the group determination o microorganisms showed a higher total biologica activity (especially involving bacteria) in flood-plain soils than in the podzolic soil of the main bank. The greatest biological activity within th limits of the flood plain was found in sod soils.

5. The intensity of the aerobic decompositic of cellulose decreases from the river-side sod soils to the meadow soils of the central flood plain and to the water-logged soils on the terra side, whereby the role of bacteria in this proce decreases and that of fungi and actinomyces increases. The decrease in sulfates in the soils increases regularly from the river to the first terrace.

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MEANS OF INCREASING THE WATERHOLDING CAPACITY OF SOILS

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In the Sarapa, Tul'a and Sverdlov Oblasts' the limiting factor in increasing crop yields with agricultural practices is the soil moisture deficiency. This is acutely felt in the Sarapa Oblast' during the entire growing season, and in the Tul'a and Sverdlov Oblasts' in May and June. To some extent the deficiency of soil moisture can be restored by wise utilization of snow. It is known that 70%-90% of snow melt runs off and creates erosion.

In 1941 the author began practical work on the State Farm No. 102 of the Zel'mansk district in Sarapa Oblast'. An attempt was made to reduce surface run-off by means of ridging and basin listing and to increase the waterholding capacity of the soil by creating a capillary perched zone at the interface of the compact — loose layers of the soil. The experiments were discontinued in 1942 and were started again in 1947 on the State Farms (Spartak, Glavskiy, Diktatura, and others) of the Tul'a Oblast'. From 1955 on analagous experiments are being conducted on the farm of the Sverdlovsk Agriculture Institute.

Ridging is accomplished by an ordinary plow in which one of the moldboards is lengthened. A similar method of operation was recommended in 1935 by Tyurnikov and Falesov (3).

In 1946, Mazharov (2) tried out ridging in the Sarapa province on the Engel'sk reclamation-experimental station.

With basin listing, more than 11,000 basins with a total capacity of 2,000 m³ are produced on each hectare. Introducing basin listing on slopes ranging from 14%-16% on the State Farm Plavskiy in the Tul'a Oblast', the author succeeded in eliminating surface run-off. However, these methods and other known methods of tillage change the waterholding capacity of the soil only very slightly; yet full utilization of the precipitation during the cold parts of the year can be accomplished by simultaneously eliminating surface run-off and increasing the waterholding capacity of the soil.

It is known that horizontal cracks in the soil increases waterholding capacity. If a layer of ground or soil is underlain with another layer of a coarser texture, its waterholding capacity will be greater than in the case of two layers of the same texture, and also greater than in the case of a finer textured layer overlain by a coarser-textured layer.

Lebedev (1) increased the waterholding capacity of a one-meter layer of soil by placing under it a 5 cm layer of sand. The moisture of this layer during the entire growing season was higher than of a similar layer without the layer of sand.

Such a method of increasing the waterholding capacity of soil has only scientific importance and at the present time cannot have any practical application. As in the case of horizontal cracks, so in the case of the layers of sand, meniscus are formed at the phase of soil-air or soil-sand. The degree to which the waterholding capacity of the soil is increased is determined by the magnitude of the menisci forc

In the course of a number of years, we created this meniscus perched zone by means of placing a loose layer under a more compact layer, both in the laboratory and in the field.

To prove that a capillary perched zone is produced on the boundary of compact and loose layers of soil, the author carried out an experiment with eight replicates. Forty-eight glass tubes, 20 cm long and 4 cm in diameter were joined in pairs to form 24 columns In eight of these columns the soil was compacted to a density of 1 g/cc. This was done in the upper tubes. The lower tubes of the same columns were filled with soil aggregates 3 mm in diameter, and were not compacted.

The second eight columns had both the upper and lower tubes filled with soil compacted to a density of 1 g/cc. The third eight columns had soil compacted to 1 g/cc in the upper tubes; the lower tubes had two layers of soil, the first layer which was in contact with the bottom of the upper layer consisted of aggregates 3mm in diameter, and was 3 cm thick. The remaining part of the lower tube was filled with non-sieved soil with a density of 1 g/cc. To each of the columns was connected a glass tube, 10 cm long, to which water was added. The water in the columns was brought to each column under the same pressure. The water supply was discontinued as soon as drops appeared on the bottom end of each column. Afte five days of drainage the soil moisture content

Table 1

oil moisture content in tubes after 5 days of drainage

Tubes in columns	Average, % of absolutely dry soil		
	Columns		
	First	Second	Third
pper	49.8	34.6	48.1
ower	50.8	48.0	49.9
verage for entire column	50.3	41.3	49.0

n the columns was determined.

As can be seen from Table 1, the capillary ressure zone was created on the boundary etween the dense and loose or aggregated ayer.

It appears from the aforesaid, and also om special set up experiments, that the ickness of the layer of aggregate does not ave an important influence on the magnitude f the menisci forces which are produced at e boundary between the soil and the loose ggregate.

The creation of the capillary perched zone t the interface of the compact soil and the ayer of aggregate is at present difficult to ring about in practice. However, with structure-producing substances, now commercially roduced, this method of increasing the water-olding capacity of the soil might become idely used.

In the second experiment the columns were omposed of six tubes, each 15 cm long and cm in diameter. The experiment was replicated eight times. The upper tubes served as e water source. In the first replicates the ower tubes of the columns (No. 6) were filled ith soil of a density of .85 g/cc; in the second ere aggregates 3 mm in diameter; and in the third, non-sieved soil with a density of 1.2 g/cc. The other four tubes (Nos. 2, 3, 4, 5) of each column were filled with soil with a density of 1.2 g/cc. Water was supplied to the columns under a constant pressure.

Table 2

oil moisture content in tubes after complete drainage

Tube No.	Average, % of absolutely dry soil in replicates:		
	1	2	3
2	47,20	50,38	42,80
3	49,33	50,23	38.53
4	53,11	52,86	39,29
5	52,97	54,19	40,17
verage for ntire column	50,65	51,91	40,17

ote: Comma represents decimal point.

When drops appeared in the lower end of tubes (No. 6) the supply of water was cut off. After five days of drainage the moisture content of the soil in the tubes was determined. (Table 2).

It can be seen from Table 2 that the capillary perched zone is created not only on the boundary between compact soil and aggregates (replicate No. 2), but also on the boundary between compact soil and loose soil (replicate No. 1).

The menisci forces which arise on the boundary between compact and loose soil are somewhat less than those which are produced on the boundary between compact soil and aggregate. However, these forces are capable of increasing the moisture content in the entire column by 10.48%, and by individual tubes from 13.83%-4.40%. (See replicates 1 and 3 in Table 2).

In order to demonstrate the effect of the thickness of the loose layer on the value of the perched capillary, we set up a special experiment consisting of four treatments. Each treatment had ten columns. The columns of the first treatment consisted of four tubes, the upper one (No. 1), 15 cm long and 4 cm in diameter, served for water supply. The second and third, of the same dimensions as the first, were filled with soil of a density of 1.2 g/cc. The fourth tube, 20 cm long, was also filled with soil of a density of 1.2 g/cc. In the columns of the second, third, and fourth treatments, the tubes 1, 2, and 3 were filled with soil with a density of 1.2 g/cc, i. e., the same as in the first treatment. The columns of the second, third, and fourth treatments differed from the columns in the first only in the density of the soil in the fourth tube. In the columns of the second treatment the fourth tube, 20 cm long, was filled with soil of a density of 0.87 g/cc. This is to say, the loose horizon in the columns of the second treatment had a thickness of 20 cm.

In the columns of the third treatment, the lower fourth tube consisted of two rings: the first, 5 cm long which was filled with soil with a density of 0.87 g/cc; the second ring, 15 cm long, had a soil with a density of 1.2 g/cc. Thus, the thickness of the loose layer and the columns of the third treatment was 5 cm. In the columns of the fourth treatment, the lower of the fourth tubes also consisted of two rings, the first one was 10 cm and was filled with a soil of a density of 0.87 g/cc; the second ring, 10 cm long, had a density of 1.2 g/cc, i. e., the thickness of the loose layer in this case was 10 cm.

The water to all the columns was supplied under constant pressure. After drops emerged through the lower tubes, five columns of each treatment were allowed to drain for five days; the other five were allowed to drain for 10 months. The columns that were allowed to drain for 10 months were protected from evaporation.

Table 3

Soil moisture after 5 days of drainage

Tube No.	Average, % of absolutely dry soil by treatments			
	Control	Thickness of loose layer of:		
		20 cm	5 cm	10 cm
2	38,73	50,63	51,14	48,64
3	40,15	54,38	53,68	54,81
Average of the two tubes	52,38	52,50	52,38	51,72

Note: Comma represents decimal point.

The average soil moisture after five days of drainage is shown in Table 3. The data in this table confirm the possibility of the creation of menisci forces on the boundary between compact and loose soil. They show that the thickness of the loose layer does not have any effect on the water-holding capacity of the soil which was determined after a five-day period of drainage. But in our experiment the thickness of the loose layer showed a significant influence on the moisture content of the soil as determined after 10 months of drainage (Table 4).

Soil moisture in the first treatment was reduced at the end of the 10 month period by 2.56%. The greatest reduction in soil moisture (13.54%) after a 10 month drainage period took place in the columns with a loose layer 5 cm thick. In the columns in which the loose layer was 10 cm thick, the soil moisture decreased by 9.78%, and where the layer was 20 cm thick, by 7.25%.

The moisture is decreased through the compaction of the loose layer. With the compaction the difference between the sizes of the capillaries in the loose and in the compact layer is diminished, which leads to the reduction of the menisci forces on the boundary between the two layers, and to the drainage of the excess moisture. The loose layer, 5 cm thick, withstands compaction by the action of the upper horizon, and by internal sloughing. The thicker the loose layer the slower it becomes compacted and the menisci forces are diminished more slowly or more gradually. It is interesting to note that the effect of the loose layer, even only 5 cm thick, is not short-lived so that, in our opinion, it has practical significance.

Table 4

Soil moisture content after 10 months of drainage

Tube No.	Average, % of absolutely dry soil by treatments			
	Content	Thickness of loose layer of:		
		20 cm	5 cm	10 cm
2	36,11	43,15	38,52	40,72
3	37,64	47,36	39,16	43,16
Average of the two tubes	36,88	45,25	38,84	41,94

Note: Comma represents decimal point.

Practical as well as scientific significance is attached to the question of the height over which the menisci forces are effective. To solve this problem we assembled 16 columns, each 50 cm tall exclusive of the water supply. Each column consisted of rings 5 cm long. In eight of the columns the lower two rings were filled with loose soil (d_1= 0.85 g/cm³); the upper, with compact soil (d_1= 1.2 g/cm³); the other eight columns had the same density in all the rings, 1.2 g/cm³. After five days of drainage the columns were dismantled and the soil moisture content was determined in each of the rings. (Table 5).

The average moisture content of the 50 cm columns of soil with a density of 1.2 g/cc was 17.94% greater when underlain by a layer with a density of 0.85 g/cm³ than when the underlying layer had a density of 1.2 g/cm³. In the presence of a loose underlying layer the soil moisture in all the rings of the columns was considerably higher than in the rings of the columns without the loose layer: the difference is 23.53% in the lower rings; 13%-15% in the middle rings; and 20%-22% in the higher rings.

The results obtained show that the menisci forces which are produced on the surface dividing the compact and loose soils are so great that their effect is clearly shown to extend to a height of 45-50 cm. Apparently it extends considerably higher since at the height of 45-50 cm the menisci forces were still capable of holding 22% more water than was held in the rings of the columns without the loose horizon. The menisci forces are formed on the boundary between soil — air as well as between compact — loose soil.

In the second case they are stronger than the first, which is attested to by the data of all tables. For instance, from Table 5 it appears that on the boundary of the compact — loose soil in the 10-15 cm layer the moisture content is 56.14%, and in the layer of 0-5 cm, the second treatment of the columns, on the boundary between the soil and the air, it is only 37.53%.

In the State Farms Plavskiy, Diktatura, Tepl Ogorevskiy, and others of the Tul'a Oblast', field experiments were carried out to verify various questions connected with the appearance of menisci forces on the boundary of compact — loose soil. In this paper we present the data of two experiments. In these experiments the loose layer was 10 cm thick. It was under a compact layer 25 cm thick, which

Table 5

Soil moisture content in tall columns after drainage

Columns with loose layers of soil			Columns with compact layers of soil		
Density of soil, g/cm³	Layer, cm	Moisture, %	Density of soil, g/cm³	Layer, cm	Moisture, %
1,2	55—60	44,15	1,2	55—60	22,14
"	50—55	43,33	"	50—55	23,19
"	45—50	43,55	"	45—50	23,03
"	40—45	43,64	"	40—45	27,16
"	35—40	44,60	"	35—40	31,78
"	30—35	46,88	"	30—35	31,70
"	25—30	46,94	"	25—30	32,69
"	20—25	51,98	"	20—25	32,75
"	15—20	47,71	"	15—20	32,57
"	10—15	56,14	"	10—15	32,61
Average moisture of soil columns (10-60 cm)	—	46,90	—	—	28,96
0.85	5—10	32,16	1,2	5—10	32,87
0.85	0—5	35,11	"	0—5	37,53
Average moisture of entire column (0-60 cm)	—	44,68	—	—	30,00

Note: Comma represents decimal point.

turn served as a underlying layer of a loose yer 5 cm thick. Altogether there were 40 m of soil worked. The first experiment was arried out in the fall of 1951 in two replicaons on a plot 4 m² on a level plot (the soil was lay loam, leached chernozem, horizons A + B 70 cm, the subsoil was a loess like clay loam). he experiment was laid out on the following cheme: KB_1, B; KB_1, B; KB_1, B; KB, BK.

As a control (K) served a common moldoard plowed area with the plowing to a depth 22-25 cm, which was accomplished with gang plow of 3 plows. The B treatment was oldboard plowed to a depth of 27-30 cm, which as deepened to a depth of 40 cm. The B_1 treatent was set up in the following manner. First, e soil was taken out in layers 5 cm thick, together 8 layers. After 35-40 cm were ken off, the surface was loosened with a rake a depth of 1-2 cm.

. On the loosened surface was placed a layer 5-40 cm, then 30-35 cm. These layers were ompacted. Then was placed the 25-30 cm yer which was compacted with a special oard. Later this layer was loosened with a ke to a depth of 1-2 cm, and on top of it was aced the 20-25 cm layer. In the same order d with the same preparation were placed the 5-20 cm, 10-15 cm, and 5-10 cm layers. he layer 0-5 cm was placed on the 5-10 cm yer, which was loosened to a depth of 1-2 n. It was not compacted. The plots, together ith the surrounding area, were harrowed in o directions in the spring. Simultaneously ith the harrowing, the plots were cultivated d seeded to oats with an addition of clover d timothy. On May 20th, and July 20th, 1952, the soil moisture was determined (Table 6).

The greatest addition of water in the case of the boundary of compact — loose soil took place in the 5-30 cm layer. It was 9% greater than on the plots plowed with deepening to 40 cm, and 12.2% greater than with the ordinary plowing to a depth of 22-25 cm.

In the 30-40 cm layer the moisture in the several treatments of the experiment did not even out. In treatment B_1 it was 3%-4% greater than in the control K and in the treatment B.

Two months afterward on July 20th, a difference in soil moisture was observed in the several treatments, although this difference was not as appreciable as in May, i. e., in the first instance it was 2.4%-2.8% greater than in the control treatment. The magnitude of water loss in the several treatments is noteworthy. With the loose layer 10.2% of water was lost in two months, while with the plowing and deepening to 40 cm, 6.06% was lost. With ordinary plowing to a depth of 22-25 cm, only 4.04% of water was lost. This can be explained not only by the fact that in the treatment with loose soil a better yield was produced, but primarily by the very small size of the plots by the movement of water in liquid and vapor form into the drier control plots.

We continued the observation of soil moisture in 1953 and 1954. On May 20, 1953 the moisture of the 0-40 cm layer with the loose layer exceeded that in the control treatment by

Table 6

Soil moisture control for treatments. Plavski state farm Tula Oblast' experiment in 1952

Layer, cm	Treatment with loose layer and compact layer in the middle of B_1		Moldboard plowed 27-30 cm deepened to 40 cm (B)		Plowed to a depth of 22-25 cm (K)	
	May 20	July 20	May 20	July 20	May 20	July 20
0—5	22,18	14,66	19,51	14,11	18,54	15,88
5—15	38,36	20,36	25,11	19,16	23,17	18,17
15—25	32,88	24,14	27,19	19,73	23,09	20,13
25—30	36,66	26,80	28,61	20,84	24,15	19,62
30—40	29,15	22,14	26,14	22,43	25,48	20,54
0—40	31,35	21,65	25,31	19,25	22,91	18,87

Note: Comma represents decimal point.

Table 7

Yields of oats and of hay of perennial grasses, kg from 4 m². Plavski state farm Tula Province

Treatment	Oats	Hay of perennial grasses	
	1952	1953	1954
Loose layer at the bottom and compact layer in middle (B_1)	2,38	3,15	2,84
Moldboard plowing 27-30 cm deepened to 40 cm (B)	1,69	2,37	2,56
Ordinary moldboard plowing 22-25 cm (K)	1,45	2,11	2,48

Note: Comma represents decimal point.

2%-3%, and on May 20, 1954, by 1%-3%. This shows that even during the third year the boundary of compact loose soil, i. e., the loose layer did not yet become compacted to the density of the upper, more dense layer.

On the several treatments the following crop yields were obtained (Table 7). Considerable increases in yields were observed both for the first crop (oats), as well as the following one with hay of perennial grass. Such increases are not only the result of accumulation of larger amounts of water, its good conservation when there is a loose underlying layer, but also of appreciable changes in growing conditions for the plants.

In the compacted layer there was observed a more energetic growth of the root system. A month after seeding we found in the 5-30 cm layers almost 45% more roots than on the control plots. The germination, survival, and vigor of the initial growth was markedly greater. In the compact layer the contact of the roots and of the root hairs with the soil was greater, which improved the nutrition of the plants, both with water and soil nutrients. The position of the compact layer between two loose ones considerably improves its thermal properties and ensures a flow of air.

When the surface of the boundary of the compact — loose soil is leveled off, the capillary forces are not fully utilized. In 1952 we set up an experiment in which basins were created on the surface of one of the treatments. On the other plots the surface was leveled so that it appeared like soil plowed with a moldboard plow and a coulter. The basins were filled with water in the spring. The water gradually soaked in. The soil moisture with the surface in basins was increased 2%-6% in comparison with those areas where there were no basins.

Conclusions

1. On the boundary between compact and se layers of soil there arise capillary ces capable of appreciably increasing the terholding capacity of overlying compact ers of soil.

2. The size of the loose layer does not ect the value of the waterholding capacity of soil, as determined immediately after inage, but does influence the length of e the moisture is retained above the ndary layer.

3. The action of the menisci forces which e created on the boundary of compact — loose l extends over a layer of soil in excess 50 cm.

4. Under practical conditions the boundary of the compact — loose soil persists for several years.

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DISTRIBUTION OF READILY MOBILE WATER IN SOILS AND SOIL MATERIALS OF VARYING STRUCTURE

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In a recently published work of Rode (9) an interesting question was raised about the direction of the process of soil formation in two-layered soil materials in which the upper, fine-textured deposit is underlain at a certain depth by a coarse-textured deposit having a sharply differing porosity.

As is known from the earlier works of Lebedev (6, 7), Zunker (14), Ryzhova (10, 11), and Kachinskiy (4), a larger amount of readily mobile water accumulates in the upper layer above the boundary surface between the fine and the coarse-textured layers than in the fine-textured soil when uniform. We can mention an even earlier work of Versluys (13), in which the author concludes on the basis of experiments, "that the so-called draining layer in lysimeters does not insure the slow drainage of water penetrating into it, as is usually assumed: the water stagnates, or better, it hangs above the draining layer."

A. A. Rode presents additional material which shows that with such a soil structural profile, the high content of readily mobile water may change the direction of the soil-formation process toward a higher hydromorphism. This new statement of the problem, which has not yet been touched by the literature, deserves greater attention. At the same time, the increase in moisture capacity of soil in heterogeneous soils underlain by gravel or coarse sand layers has another practical significance — illustrated in our earlier works on the irrigation regime of agricultural crops on such stratified soils with a high moisture capacity.

Before discussing this problem, let us examine the terminology and concepts of the foregoing phenomenon. As we know the following three types of moisture distribution may occur in a thick soil, wetted from above, after equilibrium sets in.

1. The soil is not wetted down to the ground water, or to the coarse-textured drainage layer. In this case capillary-suspended water is created, according to the terminology of A. F. Lebedev and N. A. Kachinskiy, and film-suspended, or capillary-film-suspended, water, according to the terminology of A. A. Rode. The moisture capacity corresponding to this type of water is called minimum capacity by Kossovich (5), and field moisture capacity by American authors.

2. The soil is wetted to the ground-water table. In this case the moisture of the upper layers joins with the moisture of the lower layers and forms a so-called perched capillary water, according to Kachinskiy. The moisture capacity of the lower layers, resting on the ground-water table, exceeds the minimum moisture capacity of the overlying soil layers. The perched water from the ground-water table may differ, depending on the texture and compactness of the material.

3. The soil is wetted to the draining layer which has a coarser texture and a sharp boundary surface. In this case, as was mentioned earlier, more water is retained above the boundary surface than is retained by the same fine-textured soil in the suspended state. However, in this case not all the pores of the overlying fine-textured layer are filled with water as is the case during the perched capillary water. According to the terminology of Zunker, under such conditions of equilibrium perched capillary-bound water (aufsitzendes Hartwasser) forms. Rode proposes to call this perched capillary-suspended water, which in his opinion, better reflects the nature of this phenomenon.

The foregoing types of water distribution in soils must be considered when establishing the irrigation regime of agricultural crops. Ryzhov (12), Rode (8), and others have determined that the moisture content of soil before irrigation should not drop below 70% of its minimum moisture capacity. A drop in moisture below this value leads to the slowing down of plant growth and, finally, to reduced crop yield. The foregoing lower limit of optimum soil moisture for plant growth, or the moisture of the ruptured capillaries, has been established for more or less homogeneous soil for capillary-suspended moisture conditions. I is clear that this limit must change in the case of the perched capillary water, or set capillary water, since the amount of readily mobile water is considerably greater than in the capillary-suspended state. Consequently, soil moisture before irrigation of such soils must be less than 70% of their capillary moisture capacity. It is clear that the higher the amoun of perched capillary, or set capillary water,

Table 1

Moisture distribution in light sierozem of Golodnaya Steppe at different ground-water levels, % by weight

Depth, cm	Depth, m			
	1,6	2,0	2,5	3,0
0—10	20,3	20,4	20,1	20,0
10—20	20,9	21,0	20,1	20,1
20—30	21,7	21,3	21,3	21,1
30—40	24,7	24,2	23,3	22,2
40—50	27,8	26,8	24,3	22,4
50—60	28,9	28,1	25,2	22,5
60—70	30,3	28,8	27,0	23,3
70—80	30,4	29,8	27,3	23,6
80—90	30,8	29,9	27,7	24,0
90—100	30,7	30,1	28,4	24,3
100—110	30,4	30,3	29,5	25,1
110—120	30,1	30,6	29,5	25,1
120—130	30,2	30,7	29,3	25,3
130—140	30,9	31,3	29,5	25,6
140—150	31,1	31,4	30,2	25,9
150—160	31,1	30,8	30,6	27,1
160—170	Ground water at 160 cm down	30,9	30,9	27,5
170—180	—	30,4	30,6	27,9
180—190	—	30,5	30,8	29,5
190—200	—	31,3	31,5	30,4
200—210	—	Ground water at 200 cm down	31,6	30,2
210—220	—	—	31,7	30,1
220—230	—	—	31,7	30,2
230—240	—	—	31,1	30,3
240—250	—	—	31,4	31,1
250—260	—	—	Ground water at 250 cm down	31,2
250—270	—	—	—	31,2
270—280	—	—	—	31,6
280—290	—	—	—	31,7
290—300	—	—	—	31,9
				Ground water at 300 cm down
0—50	23,1	22,7	22,0	21,1
0—70	24,9	24,4	23,0	21,6
0—100	26,6	26,0	24,5	22,4
0—150	28,0	27,7	26,2	23,4

Note: Comma represents decimal point.

e lower the moisture must drop before rigation, if it be calculated in percent of pillary moisture capacity.

Let us examine our data on the distribution moisture in the perched capillary state at different ground-water levels (Table 1).

Moisture distribution in this case was determined in the same area, but at different times, when the ground water was at different depths. In all cases, even when the ground water was at a depth of three meters, water rose almost to the soil surface, which greatly increased the moisture in each layer. The moisture of the given soil in a state of capillary rise was 20%-22%, which coresponds to the minimum moisture capacity of other soils when the ground water is deep. The same data indicate that the capillary rise of water in these soils was about three meters.

Thus a considerable amount of water available to plants is created by the high support of capillary-suspended water by ground water. If in the capillary-suspended state, when minimum moisture capacity is 20%-22%, the lower limit of optimum moisture in these soils is 14%-16%. Under barrier conditions of this moisture, when its content in the root zone increases to 24%-26%, the rupture of capillary moisture remains the same, equal to 14%-16% of their weight.

Consequently, when barrier of suspended water is high, the lower limit of optimum soil moisture at which irrigation must be started is not 70% of the capillary moisture capacity, but 55%-65%.

The soils of Golodnaya Steppe developed on silty, large-pore, friable loess deposits having a high and intense capillary rise capacity. In other, finer-textured and more compact soils having a minimum moisture capacity of 24%-25 the rise by ground water does not usually exceed 0.5-1 m (Table 2).

The moisture capacity of the given soil was also determined in the same area, but at different times and at different ground-water levels.

As may be seen from the given data, the height of the support by ground water here does not exceed 40-50 cm. It is clear that in this case the lower limit of optimum moisture before irrigation would be the same in percent

Table 2

Moisture distribution in fine clay loam at different ground-water levels, % by weight and volume

Depth of layer, cm	Depth, cm				Bulk density	Depth of layer, cm	Depth, cm				Bulk density
	100		150				100		150		
	By weight	By volume	By weight	By volume			By weight	By volume	By weight	By volume	
0—10	30,7	35,9	29,9	35,0	1,17	80—90	27,6	43,9	24,6	40,1	1,59
10—20	29,0	35,5	29,3	35,7	1,22	90—100	28,6	45,4	24,8	39,4	1,59
20—30	24,6	32,7	24,1	32,0	1,33	100—110	—	—	25,4	40,6	1,60
30—40	24,8	37,4	24,2	36,5	1,51	110—120	—	—	26,3	41,5	1,58
40—50	23,1	32,5	23,5	33,1	1,41	120—130	—	—	27,2	42,4	1,56
50—60	24,1	37,4	23,9	37,0	1,55	130—140	—	—	27,6	43,3	1,57
60—70	26,4	40,9	24,8	38,4	1,55	140—150	—	—	28,3	41,0	1,45
70—80	27,2	43,8	24,3	39,1	1,61						

Note: Comma represents decimal point.

Table 3

Bulk density of light sierozems of Golodnaya Steppe

Depth, cm	Depth of ground water, m				Depth, cm	Depth of ground water, m			
	2	3	4,2	6,9		2	3	4,2	6,9
0—10	1,30	1,31	1,28	1,28	110—120	1,33	1,35	1,36	1,33
10—20	1,32	1,34	1,31	1,28	130—140	1,33	1,34	1,33	1,36
20—30	1,42	1,43	1,38	1,34	150—160	1,35	1,34	1,31	1,34
30—40	1,43	1,40	1,41	1,36	170—180	1,35	1,35	1,34	1,35
40—50	1,34	1,32	1,36	1,31	190—200	1,34	1,35	1,32	1,33
50—60	1,34	1,34	1,35	1,33	240—250	—	1,32	1,34	1,34
60—70	1,34	1,35	1,34	1,38	290—300	—	—	1,35	1,36
70—80	1,38	1,36	1,38	1,34	340—350	—	—	—	1,38
80—90	1,34	1,34	1,34	1,35	390—400	—	—	—	1,36
90—100	1,35	1,34	1,35	1,34					

Note: Comma represents decimal point.

weight at various times and with varying ound-water levels, but vary in percent of oisture capacity.

We studied the distribution of moisture ong the soil profile in thicker, homogeneous ils at varying ground-water levels together th N. F. Besplavnyy. The same soil was etted from the surface to the ground-water table in one case, and to the upper boundary of the capillary fringe in another case. Moisture distribution was determined layer by layer 4-5 days later. It proved that soil moisture was different in the first and in the second case (Tables 3 and 4).

The investigations were conducted in Golodnaya Steppe in virgin or recently reclaimed land

Table 4

Moisture distribution in light sierozems of Golodnaya Steppe at different ground-water depths, % by weight of absolutely dry soil

Depth, cm	Depth, m							
	2		3		4,2		6,2	
	To the ground-water table	To the capillary fringe	To the ground-water table	To the capillary fringe	To the ground-water table	To the capillary fringe	To the ground-water table	To the capillary fringe
0—10	20,1	20,4	20,0	20,3	20,1	19,9	19,8	20,2
10—20	20,1	20,6	20,1	21,2	19,8	20,3	20,3	20,3
20—30	21,3	21,3	21,1	21,4	20,4	20,8	20,2	20,6
30—40	23,2	22,8	22,2	22,6	20,6	20,3	21,1	21,0
40—50	24,3	23,6	22,4	22,3	20,8	20,8	21,0	21,3
50—60	25,2	21,7	22,5	22,6	21,0	21,2	20,8	20,6
60—70	27,0	21,8	24,3	22,8	20,8	21,3	21,2	21,3
70—80	27,3	22,4	23,6	23,2	21,6	21,8	20,7	21,4
80—90	27,7	23,5	24,0	21,8	21,2	21,9	19,9	20,8
90—100	28,4	25,4	24,3	22,8	21,3	22,0	20,3	20,9
100—120	29,5	26,0	25,1	23,4	21,4	21,7	21,1	21,4
120—140	29,5	27,1	25,5	23,6	21,3	21,3	20,8	21,3
140—160	30,4	27,5	26,5	24,5	21,8	20,9	19,7	19,8
160—180	30,7	28,0	27,7	24,8	23,9	21,8	19,8	20,1
180—200	31,2	29,3	29,8	25,7	23,9	20,9	20,3	20,6
200—220	—	—	30,2	26,8	22,8	21,6	19,9	19,8
220—240	—	—	30,3	26,3	23,5	22,5	20,1	20,4
240—260	—	—	31,1	26,5	25,6	23,3	21,4	21,3
260—280	—	—	31,4	27,4	26,4	23,4	20,6	20,7
280—300	—	—	31,8	29,8	26,5	23,5	20,4	19,3
300—320	—	—	—	—	27,8	24,6	21,3	18,6
320—340	—	—	—	—	28,6	24,8	24,8	19,2
340—360	—	—	—	—	29,8	25,8	25,9	20,0
360—380	—	—	—	—	30,6	27,4	25,1	22,6
380—400	—	—	—	—	30,8	28,6	25,6	22,2
400—420	—	—	—	—	31,2	29,8	26,7	22,5
420—440	—	—	—	—	—	—	26,5	23,0
440—460	—	—	—	—	—	—	26,3	24,0
460—480	—	—	—	—	—	—	26,4	24,6
480—500	—	—	—	—	—	—	28,8	25,3
500—520	—	—	—	—	—	—	28,4	26,7
520—540	—	—	—	—	—	—	29,8	26,9
540—560	—	—	—	—	—	—	30,2	27,1
560—580	—	—	—	—	—	—	31,3	27,3
580—600	—	—	—	—	—	—	30,3	28,6
600—620	—	—	—	—	—	—	31,4	29,8
0—100	24,5	22,4	22,4	22,1	21,0	21,0	20,5	20,8
100—200	30,4	27,6	26,9	24,4	22,5	21,3	20,3	20,6
200—300	—	—	30,9	27,4	25,0	22,9	20,5	20,1
300—400	—	—	—	—	29,5	26,2	24,5	20,4
400—500	—	—	—	—	—	—	26,9	23,9
500—600	—	—	—	—	—	—	30,0	27,3

e: Comma represents decimal point.

of almost the same compactness, almost the same texture, but at different ground-water levels.

As may be seen from Table 4, the moisture of the upper soil layers in all areas, independent of the depth of ground water, was 20%-21%, which was their minimum moisture capacity. Lower, beginning from the zone of ground-water barrier, moisture gradually increased. However, moisture in the capillary rise zone in all areas was always higher when the soil was wetted to the ground-water table, than when it was wetted to the capillary fringe. This difference averaged 1.5%-2.5% of soil weight. From the foregoing data we may conclude that when wetting the soil from the surface down to the ground water table, more moisture is retained in the lower layers than in the same layers under capillary saturation from below.

The phenomenon established by us may be considered as the fourth case of moisture distribution in soils when wetting them from the surface down to the upper boundary of the capillary fringe.

The minimum moisture content of the given soil in a capillary-suspended state is 20%-21%, while from the barrier of ground water it gradually increases with depth to full capillary saturation. The barrier of ground water affects the increase of readily mobile water to a height of 2.5-3.0 m.

Undoubtedly this increase in the content of readily mobile moisture can be easily utilized by plants. It is clear that the lower limit of optimum moisture for plant growth must differ in individual soils layers, but in all cases it will be below 70% of minimum moisture capacity.

Thus the moisture contents available to plants in the same soil, but at different ground-water levels, would vary. In view of this, irrigation periods must also differ. This important condition refers primarily to hydromorphous soils of a loess-like nature in which the ground-water barrier is very high, up to 2-3 meters. In finely-textured soils with a compact structure, a high minimum moisture capacity, and a low ground-water barrier, the lower limit of optimum moisture varies little. Another reason why we discussed this question in detail is that in a recently published work of Yeremenko (3) we encountered a non-comprehension of the theoretical principles of the determination of the lower limit of soil moisture before the irrigation of cotton. Incorrectly interpreting the data given in his article, V. Ye. Yeremenko writes: "The assertion that the rupture of capillary moisture corresponds to the lower limit of allowable moisture in the root zone cannot be considered as proved." And further: "Thus, the data obtained allow one to assume that the lower limit of allowable soil moisture before irrigation must be determined from actual soil conditions and the growing period of cotton, and not by the rupture of capillary moisture."

V. Ye. Yeremenko should have known that the rupture of capillary moisture precisely reflects actual soil conditions and is 70% of the minimum moisture capacity only for homogeneous layers with capillary-suspended water. As was shown in the works of Abramova (1), and Bol'shakova (2), with this type of moisture the capillary continuity of the water network is disturbed and the rate of water movement is sharply reduced. In comparing Abramova's and Bol'shakova's data on sierozem soils with our data on the same soils (12), Rode (8) concluded that the rupture of capillary moisture is identical with the lower limit of optimum soi moisture before irrigation (p. 385).

As shown by the foregoing data, one and the same soil will contain a different amount of readily mobile water depending on the depth of the ground-water level and the depth of the draining layers at one and the same rupture of capillary moisture (percent by weight). It is clear that the irrigation regime of plants on this soil must also vary. Only with a more or less homogeneous structure of soils without sharp alternations in texture or porosity of individual layers, will the lower limit of soil moisture before irrigation be about 70% of the minimum moisture capacity.

The experimental material collected at random by V. Ye. Yeremenko, without reference to authors and without an analysis of actual soil conditions, does not show at all that the rupture of capillary moisture does not correspond to the lower limit of allowable moisture in the root zone before irrigation.

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ANNUAL CROPS AS A FACTOR IN THE AGGREGATION AND STRUCTURE DEVELOPMENT OF CHERNOZEM SOILS

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Modern agricultural soil science considers the structure-aggregate composition of soil as an important condition of its fertility. But at present, there is no unified, scientifically substantiated point of view on methods of restoring and improving the structure-aggregate properties of chernozem soils.

V. R. Vil'yams (2) affirmed that only perennial grasses enrich the soil with organic substances, restore its structure, and increase its fertility. T. S. Mal'tsev (6) believes that under certain conditions annual crops may also create soil structure and increase its fertility.

In spite of the differences in the recommendations for systems of agricultural melioration, both Vil'yams and Mal'tsev proceed from the assumption of the leading role of structural and aggregate composition in the fertility of chernozem soils.

Agricultural experiments, especially those of recent years, have shown that under arid conditions, where perennial grasses often give a low yield, their influence on the physical properties of soil becomes insignificant. Even when perennial grasses yield enough hay and increase the content of water-stable separates, the yield of following crops in grassland farming is lower than in row crop rotation, because of the considerable desiccation of soil during their growing period and deficient atmospheric precipitation.

The experimental material available at present is not sufficient to substantiate scientifically the assumption that annual crops improve the fertility of chernozem soils.

I. V. Tyurin (8) generalized the material of the complex brigade of the Academy of Sciences of the USSR assigned the study of the Mal'tsev system of soil tillage at the Shadrin experimental station. He concluded that T. S. Mal'tsev's assumption that under his system of tillage annuals can accumulate humus, create soil structure, and increase the fertility of soil, is not always true.

S. A. Vorob'yev (3) concluded that annual field crops have a positive effect on the fertility of soil during the growing period in that they increase the content of organic substances and that of structural units of optimum size. It is noted that such an effect is not uniform and depends on the biological characteristics of plant These investigations established also that fact which worsen the most important soil properti become stronger under annual crops than unde perennial grasses. Without examining this pr lem in more detail, one may say that methods improving the conditions of fertility of chernozem soils have not yet been studied.

Taking into account that the problem of aggregate and structural development must be solved under definite physiographic conditions, we have been studying for the last 4 years (195 1957) the role of annual crops and perennial grasses in the changes of conditions of fertilit of chernozem soils in the southern part of the Trans-Volga forest steppe. To obtain reliable indices in a sufficiently short time, we conducted our experiments by the laboratory-fiel method, using bottomless metal containers 40 cm high and 25 cm in diameter. The soil for i vestigation (ordinary chernozem with 7.7% hum was taken from the experimental field of the Kuybyshev Agricultural Institute. The contain were placed into holes of a corresponding size the experimental area of the Chair of Agriculture. The soil was sieved through a 3 mm dia meter opening sieve before being placed in the containers to make its structural and aggregat composition more uniform and to increase the amount of silty elements in the initial soil. Wh filling the containers the soil was compacted t bulk density equal to one. Before sowing the crops, soil moisture in the containers was bro to field moisture capacity. During the growing period the containers were watered twice with 30 mm of water per container. After the shoo appeared, the number of plants left was such a to correspond to the nutrition area of the crops sown. The experiment was replicated 3 times During 4 years, the following alternation of cr was used (see experimental setup).

During the first year of investigation variou crops were used, then after Sudan grass, oats were used for 2 years and then spring wheat w sown in the fourth years in the first experime treatment. In the second treatment oats were sown for 2 years after spring wheat, and then spring wheat was sown again in the final year. the third treatment oats were used for 3 years and spring wheat on the fourth year. In the fou and fifth treatments a mixture of grass-legum was used in the first 3 years, and spring whea

Experimental setup

Treatments	Years and crops			
	1954	1955	1956	1957
First	Sudan grass	Oats	Oats	Spring wheat
Second	Spring wheat	Oats	Oats	Spring wheat
Third	Oats	Oats	Oats	Spring wheat
Fourth	Brome grass + sainfoin, 1 year	Brome grass + sainfoin, 2 years	Brome grass + sainfoin, 3 years	Spring wheat
Fifth	Alfalfa + Agropyron, 1 year	Alfalfa + Agropyron, 2 years	Alfalfa + Agropyron, 3 years	Spring wheat
Sixth	Fallow	Rye	Oats	Spring wheat
Seventh	Fallow	Fallow	Fallow	Fallow

e fourth. The sixth treatment consisted of a tation of winter rye, oat, and wheat on black low, and the seventh treatment was left unsturbed in a fallow state.

The experiments were accompanied by evalung the yield of tops and roots, and by the idy of the dynamics of humus, and the strucral and aggregate composition of soil. Roots l organic residues were determined by wash; in sieves after soaking the soil blocks in etal boxes. Soil humus was determined by e Tyurin method. The content of water-stable gregates and structural separates was dermined by shaking the sieves, and the microgregate composition, by the usual pipette ethod of Robinson.

Table 1 shows the yield of tops and roots of crops during the first year after sowing; ble 2 shows the yield of spring wheat and the ganic content after the major preceding crops.

As can be seen, the highest yield of tops and ots was obtained in treatments with Sudan ass-legume mixture.[1] However, the widest tio between the yield of top and roots in all ses occurred with annuals. Even in the first ar, perennial grass-legume mixtures had a her yield of roots than annuals. A wider tio between shoot and root remains was obrved after annual predecessors as compared perennial grass at the end of the experiment ıble 2).

It also follows from Table 2 that the most orable conditions for the growth and develop- nt of spring wheat were created by perennial ass-legume mixtures. The yield of the spring eat tops after perennial grasses was noticey higher than after grain crops.

Among perennial grass mixtures the greatest ring wheat yield was obtained after brome grass with sainfoin. The yield was somewhat lower after Agropyron with alfalfa. A good predecessor for spring wheat among the annuals used in the experiment was oats sown after oats and Sudan grass (as compared to oats used as the third crop after oats, wheat and black fallow).

The different content of organic residues in the soil after annuals and perennial grasses had an effect on the physicochemical properties of the soil.

The dynamics of soil humus in the various treatments is shown in Table 3. As may be seen, the quantitative composition of humus varies little in the various treatments. Mathematical analysis of the indices obtained showed that true variations in the humus content occurred only in the treatments with perennial grasses and in containers under fallow; in these cases the index of accuracy ($t = \frac{M_1 - M_2}{md}$) varies from 2.59-5.86. However, when growing annuals, the humus content decreases somewhat as a rule; this is especially noticeable in soils

Table 1

Yield of tops and roots of perennial and annual crops the first year after sowing, grams[a]

Crop	Yield of tops	Roots in the 0-40 cm layer	Ratio of tops to roots
Sudan grass	146,7	18,7	7,8
Spring wheat	14,7	2,0	7,3
Oats	8,0	1,4	5,7
Brome grass, sain.	28,6	11,7	2,4
Agropyron, alfalfa	26,7	20,5	1,3

[a] After the harvest of the tops and the washing of roots (crops after the first year of sowing) the experiment was still repeated twice.

Note: Comma represents decimal point.

The high yield of Sudan grass and grass-legume tures is attributable to the fact that the first had a d tillering stage and yielded 3 cuttings of hay, while grass-legume mixtures gave 2 cuttings. The yield ats was lower than that of spring wheat in all tests.

Table 2

Yield of spring wheat and the content of organic residues in soil after various predecessors

Predecessors of spring wheat, 1954-1957	Yield of tops		Organic residues in the 0-40 cm layer in grams	Ratio between tops and organic residues
	in g	in %		
Oats after oats and Sudan grass	22,0	122	8,1	2,5
Oats after oats and oats	18,4	102	7,0	2,6
Oats after winter rye and black fallow	18,9	105	7,6	2,5
Oats after oats and wheat	18,0	100	7,1	2,6
Brome grass with 3 years of sainfoin	29,2	162	46,4	0,6
Agropyron with 3 years of alfalfa	24,4	135	46,6	0,5

Note: Comma represents decimal point.

under fallow. A certain increase in humus content occurs under perennial grasses as compared with the initial soil. The investigations show that a considerable increase in the amount of humus occurs when the soil contains the largest amount of root residues. Even though the annuals had a lesser amount of root residue than perennial grasses, they still increased the

Table 3

Influence of annual crops and perennial grasses on the humus content in soil, %

Crop sequence (1934-1957)	Soil layer, cm	Humus content at the end of the experiment (M-average; M±variance squared)	Increase (+) or decrease (-) as compared to the initial	Content of organic residue at the end of the experiment after harvest of wheat, g
Spring wheat after 2 years of oats and Sudan grass	0—10 10—25 25—40	7,55±0,016 7,53±0,029 7,57±0,025	—0,16 —0,18 —0,14	5,58 2,08 0,45
Spring wheat after 2 years of oats and spring wheat	0—10 10—25 25—40	7,53±0,037 7,51±0,025 7,54±0,020	—0,18 —0,20 —0,17	5,00 1,64 0,46
Spring wheat after 3 years of oats	0—10 10—25 25—40	7,51±0,050 7,55±0,008 7,53±0,037	—0,20 —0,16 —0,18	4,55 2,07 0,41
Spring wheat after 3 years of Brome grass with sainfoin	0—10 10—25 25—40	7,83±0,050 7,82±0,042 7,75±0,033	+0,12 +0,11 +0,04	33,69 8,36 4,40
Spring wheat after 3 years of alfalfa with Agropyron	0—10 10—25 25—40	7,86±0,050 7,80±0,041 7,78±0,038	+0,15 +0,09 +0,07	32,67 8,00 5,95
Spring wheat after oats, winter rye and black fallow	0—10 10—25 25—40	7,52±0,050 7,50±0,025 7,57±0,029	—0,19 —0,21 —0,14	0,92 0,45 0,26
Four years of black fallow	0—10 10—25 25—40	7,41±0,041 7,43±0,025 7,50±0,008	—0,30 —0,28 —0,21	— — —

Note: Comma represents decimal point.

Table 4

Influence of annual crops and perennial grasses on the structural properties of soil

Crop sequence (1954-1957)	Soil layer, cm	Contents of water-stable units > 0.25 mm in diameter at the end of the experiment (M±) %	Increase (+) or decrease (-) as compared to the initial
Sudan grass, oats, oats, wheat	0—10	48,0±0,72	—2,5
	10—25	51,7±0,80	+1,2
	25—40	59,8±0,52	+9,3
Wheat, oats, oats, wheat	0—10	45,6±0,80	—4,9
	10—25	52,2±0,68	+1,7
	25—40	53,8±0,55	+3,3
Oats, oats, oats, wheat	0—10	44,0±0,65	—6,5
	10—25	50,5±0,75	0,0
	25—40	57,4±0,52	+6,7
Brome grass + sainfoin, brome grass + sainfoin, brome grass + sainfoin, wheat	0—10	55,6±0,60	+5,1
	10—25	50,9±0,61	+0,4
	25—40	63,0±0,41	+12,6
Alfalfa + Agropyron, alfalfa + Agropyron, alfalfa + Agropyron, wheat	0—10	54,6±0,85	+4,1
	10—25	57.5±0,76	+7,0
	25—40	60,9±0,52	+10,4
Fallow, winter rye, oats, wheat	0—10	46,2±1,00	—4,3
	10—25	54,2±0,85	+3,7
	25—40	56,4±0,72	+5,9
Fallow, fallow, fallow, fallow	0—10	41,9±0,96	—8,6
	10—25	51,9±0,90	+1,4
	25—40	55,9±0,85	+5,4

Note: Comma represents decimal point.

umus supply in the soil. This is evidenced to certain degree by the fact that fallow soil, hich was bare of vegetation for 4 years, lost ore humus than the soil under annuals. The ta also show that the most intense mineralizaon of organic substances occurs in the upper 0 cm) soil layer and is slowed down somehat in the 25-40 cm layer. Thus, for instance, e reduction of the humus content in the upper rtion of the plowed layer in the containers ith fallow soil reached 0.30%, and in the 25-40 n layer, only 0.21%. The greater losses in umus in the plowed layer as compared to the ıb-plowed layer under annual crops are obably attributable to the fact that the upper yer is loosened every year to a depth of 5-6 n after the harvest, while the sub-plowed yer remains undisturbed for 4 years. In spite the high content of plant residues in the uper soil layer, their decomposition under anıal crops proceeded to full mineralization and umus accumulation was low. The increase in umus under perennial grasses occurs primari- in the upper portion of the plowed layer. This n probably be attributed not only to the higher ntent of plant residues here, but also to the ct that this layer was not loosened while it was covered by grasses. The abstention from loosening in the presence of a considerable amount of plant residues promotes an increase in the amount of humus.

The content of water-stable aggregates and structural units is shown in Table 4. The data show that the amount of water-stable aggregates increased somewhat in all treatments as compared with their initial content in the layers below 10 cm. A decrease in the content of water-stable aggregates occurred in the 0-10 cm layer, especially in fallow soil. An increase in water-stable units occurred throughout all the horizons investigated in soil under perennial grasses. An important fact is that the improvement of the structural properties of soil in all treatments occurred primarily in the 25-40 cm layer. The content of structural units also increased up to 5%-6% in the 10-40 cm layer of fallow soil.

A mathematical treatment of the data obtained showed that the changes in the structural composition in the upper (0-10 cm) and lower (25-

Table 5

Influence of annual crops and perennial grasses on the dynamics of micro-units of soil aggregates

Crop sequence	Depth, cm	Content of aggregate units at the end of experiment, % (M ±)		Increase (+) or decrease (-) as compared to the initial		Total >0.05 mm in diameter	
		> 0,25	0,25 — 0,05	> 0,25	0,25 — 0,5	after experiment	increase (+) or decrease (-)
Sudan grass, oats, oats, wheat	0—10	30,0±0,30	61,9±0,64	—9,2	+10,1	91,9	+0,9
	10—25	36,7±0,25	56,7±0,35	—2,5	+4,9	93,4	+2,4
	25—40	36,7±0,36	56,7±0,30	—2,5	+4,9	93,4	+2,4
Wheat, oats, oats, wheat	0—10	27,2±0,72	65,5±0,40	—12,0	+13,7	92,7	+1,7
	10—25	35,8±0,20	57,8±0,25	—3,4	+6,0	93,6	+2,6
	25—40	36,5±0,30	57,5±0,36	—2,7	+5,7	94,0	+3,0
Oats, oats, oats, wheat	0—10	28,3±0,20	63,9±0,35	—10,9	+12,1	92,2	+1,2
	10—25	31,8±1,00	60,3±0,64	—7,4	+8,5	92,1	+1,1
	25—40	35,4±0,25	57,4±0,15	—3,8	+5,6	92,8	+1,8
Brome grass +sainfoin 1st year; same 2nd and 3rd years; wheat	0—10	38,2±1,90	60,4±0,30	—1,0	+8,6	98,6	+7,6
	10—25	40,5±1,30	58,2±0,15	+1,3	+6,4	98,7	+7,7
	25—40	44,1±1,90	54,1±0,64	+4,9	+2,3	98,2	+7,2
Alfalfa + Agropyron 1st year; same 2nd and 3rd years; wheat	0—10	38,8±1,90	60,2±0,25	—0,4	+8,4	99,0	+8,0
	10—25	42,1±1,30	56,6±0,15	+2,9	+4,8	98,7	+7,0
	25—40	45,2±1,90	53,8±0,64	+6,0	+2,0	99,0	+8,0
Fallow, rye, oats, wheat	0—10	28,5±0,15	64,5±0,15	—10,7	+12,7	93,0	+2,0
	10—25	34,7±0,36	58,1±0,30	—4,7	+6,3	92,8	+1,8
	25—40	39,6±0,36	54,3±0,64	+0,4	+2,5	93,9	+2,8
Fallow, fallow, fallow, fallow	0—10	28,3±0,20	63,3±0,20	—10,9	+11,5	91,6	+0,6
	10—25	30,4±1,30	61,4±1,30	—8,8	+9,6	91,8	+0,8
	25—40	34,4±0,60	57,0±0,35	—4,9	+5,2	91,3	+0,3

Note: Comma represents decimal point.

40 cm) layers of soil are true, the observed accuracy $(t = \frac{M_1 - M_2}{md})$ in all treatments being more than 3; only the accuracy for the 0-10 cm layer in the first and sixth treatments is somewhat less. As far as changes in the structural composition of the middle portion of the investigated soil layer are concerned, they are, as a rule (with the exception of treatment 5), outside the limits of accuracy of the observations.

Thus, the experimental material shows that aggregate and structural formation in chernozem soils may occur to a certain degree even in the case when neither perennial grasses nor annual crops are sown. The organic residues of previous years and humus, by being subjected to decomposition by soil microorganism promote aggregation and structural development of soil. The processes of formation and destruction of structural units as well, and the process of aggregation and dispersion take place simultaneously, but in the upper part of the plowed layer dispersion and the destructio of the structure are more pronounced than aggregation and structural development.

It follows from the experimental data that th improvement in the structural properties of so under annual plants and, especially in the subplowed horizon of fields under fallow, is very weak and cannot insure the stable and continuo increment of structural units which play a positive role in the increase of soil productivity. Rotmistrov established that the root system of grain crops begins to die off at the moment of bloom, while perennial grasses can interact with the soil from the moment of growth in the spring to autumn frosts, especially in the seco year of growth. The duration and intensity of life of plants determine the amount of organic material accumulated by them, which is a material factor in the soil-formation process. Th

Table 6

Yield of tops and root residues of perennial grasses and annual crops in an average of 3 years (1957-1959, cntr/ ha)

Crop	Top yield (hay)	Root residues in the 0-40 cm layer (air-dry mass)	Ratio between tops and root remains
Alfalfa +brome grass after 2 years	36,8	84,9	0,43
Alfalfa +Agropyron after 2 years	34,2	76,0	0,45
Sainfoin +brome grass after 2 years	36,7	66,5	0,55
Sainfoin + Agropyron after 2 years	33,4	67,4	0,50
Sudan grass	43,0	32,2	1,34
Sudan grass +peavine	41,1	37,6	1,09
Oats for hay	34,7	19,2	1,80
Oat +peavine	36,3	22,4	1,62
Corn	216,7 (green tops)	29,6	—

Note: Comma represents decimal point.

uration of the growing period of certain annual
rops (potato, beet, corn, cotton) does not in-
ure the accumulation of humus, because of the
pecial practices of growing these row-crops.

The formation of active humus and a stable
tructure undoubtedly occurs to a great extent
ith the participation of rhizosphere bacteria
uring the life time of the plants. The energy
or rhizosphere bacteria is supplied by organic
nd mineral substances secreted by the roots of
lants as well as by root hairs which die off.

To acquire a stable structure, soil requires
ne accumulation of a certain amount of active
umus to form films around most of the ag-
regates. The shorter life of annual crops
imits the possibility of the formation of a stable
tructure in their rhizosphere. Only if annual
rops are very productive can they be counted on
o exert a positive influence on soil.

It must be noted that a positive role in the in-
rease of soil fertility, especially in the arid
egions of the chernozem belt, is played not only
y structural-aggregate separates >0.25 mm in
iameter, but also by small soil aggregates.
hus, in one of the pot experiments conducted
y us as early as 1938, for example, it was
stablished that the yield of spring wheat and
ats increases with decreasing soil aggregates.
he greatest yield was obtained in the case when
ne soil consisted of units <0.5 in diameter. A
eduction in the size of the units (<0.1 mm)
roduced a noticeable decrease in yield.

Our earlier studies proved that under field
onditions soil possesses the most favorable
roperties in the case when the plowed layer
onsists of aggregates 0.25-5 mm in diameter.
n increase in the size of aggregates worsens
ne water and nutritional regime of the soil. In
elation to this we paid special attention in our
ivestigations to the dynamics of microstructur-
l units in chernozem in relation to the crops
rown.

Table 5 shows the results of microaggregate analysis for the corresponding treatments. After 4 years of growing annual crops and perennial grasses, noticeable changes occurred in the soil studied. First of all, the content of aggregates >0.25 mm in diameter decreased somewhat in all treatments, except the perennial grasses.[2] At the same time the content of microstructural units 0.25-0.05 mm in diameter increased, especially in the upper part of the plowed layer. It must be noted that the absolute content of microaggregates is very high, reaching 65% in individual cases.

An investigation of the authenticity of the observations permits us to affirm that the established principles of the dynamics of the microstructural composition of soil are objective. In all the comparisons between treatments and soil horizons, the accuracy was below the required value in 5 cases only.

Microstructural aggregates in the chernozem soil zone must play a positive role in the accumulation and retention of moisture in the soil. In addition, the control for the most complete utilization of atmospheric precipitation and irrigation water must be conducted by first increasing the agricultural level (crop rotation, soil tillage, maintenance of sowings, etc.). The importance of the structural and aggregate composition will increase immeasurably if the agricultural level is increased.

Along with laboratory-field investigations on the role of annual crops and perennial grasses in the change of the conditions of fertility of chernozem soils, field investigations were also made in 1957-1959. The experiments were made

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[2] Certain differences in the amount of water-stable units in the experimental treatments shown in Tables 4 and 5 are attributable to the methods of analysis. In microaggregate analysis the action of water on the soil is more prolonged and stronger than in aggregate analysis.

Table 7

Effectiveness of annual and perennial grass-legume mixtures as predecessors of spring wheat (1958-1959)

Predecessors	Spring wheat yield	
	In cntr/ha	in %
Alfalfa +brome grass	22,8	120,6
Alfalfa +Agropyron	21,7	114,8
Sudan grass with peavine	21,7	114,2
Corn	21,4	113,2
Sainfoin + Agropyron	21,0	111,0
Oats + peavine	21,0	111,0
Sudan grass	20,3	110,2
Sainfoin + brome grass	20,1	106,0
Oats for hay	18,9	100,0

Note: Comma represents decimal point.

against the background of experimental crop rotation in the experimental field of the Kuybyshev Agricultural Institute. Annual crops were grown in 5-crop rotations on plowed fallow in the following sequence: 1) fallow, 2) winter rye, 3) annual grasses and corn, 4) spring wheat, and 5) spring wheat. The annual crops included: Sudan grass, a mixture of Sudan grass with peavine, oats for hay, and a mixture of oats with peavine and corn. The area of the plot was 450 m² with 4 replications.

Perennial mixtures of grasses and legumes were grown in two identical 9-field grass-rotations with the following crop sequence: 1) black fallow, 2) winter rye, 3) a spring crop with an admixture of grasses, 4) first-year perennial grasses, 5) second year perennial grasses, 6) spring hard wheat and millet, 7) spring soft wheat, 8) row crop, and 9) spring crop. During the second crop rotation spring hard and spring soft wheat were sown after sod of perennial grasses. The perennial grasses used in the investigation included: alfalfa with brome grass, alfalfa with Agropyron, and sainfoin with Agropyron. The area of the plot was 600 m² and the tests were replicated 4 times.

The soil of the area was of a homogeneous composition and consisted of typical moderately humic, fine clay loam chernozem of a medium thickness. The year 1957 was very dry; precipitation for 4 months (May, June, July, August) was 139.8 mm at a normal of 163.9 mm, whereby May had 5.2 mm (instead of the normal of 39 mm) and June 13.7 mm (instead of a normal of 33.8 mm) of rain. The following years were more favorable as far as the amount of precipitation was concerned. In 1958 these same 4 months had 226.7 mm of precipitation, and in 1959, 154 mm.

The investigations were accompanied by evaluating the yield of tops and roots of annual crops and perennial herbs, as well as of their influence of the properties of soil and the yield of following crops under crop rotation. The average 3-year yield of hay and the supply of root remains of annual and perennial herbs is shown in Table 6.

The data indicate that perennial herbs gave a good yield of hay, whereby the yield was obtained from the mixture of legumes with brome grass. Among the annual herbs the highest yield was obtained from Sudan grass and the mixture of Sudan grass with peavine, which exceeded the yield of alfalfa and sainfoin by 5-7 cntr/ha.

Second year perennial herbs left a large amount of roots behind them. The ratio betwee tops and roots was about 1:2, while for annual herbs it was 1:0.5 or 1:1. Thus, even annual crops may leave a large amount of roots in the soil, when giving a high yield of tops.

Perennial herbs, which accumulate more root residues in the soil than do annual crops, produce a more noticeable increase of water-stable structural units than do annual crops.

Annual and perennial herbs, by improving th fertility of chernozem soils, insure favorable conditions for the growing of following crops. Table 7 shows the 2-year average yield of soft spring wheat of the variety Lyutestsens 801 was sown after annual and perennial herbs. In 2 years it averaged 20.8 cntr/ha after annual cro and 21.4 cntr/ha after perennial herbs. Thus, under the favorable precipitation conditions of 1958 and 1959, spring wheat gave almost the same yield after annuals as well as perennial herb-legume predecessors and after corn. In dry years annual predecessors of spring wheat are usually more effective.

Conclusions

1. The investigations showed that certain annual agricultural crops (Sudan grass, and Sudan grass with peavine), and perennial herb-legume mixtures (alfalfa with brome grass and alfalfa with Agropyron), have a positive effect on the conditions of fertility of chernozem soils of the Trans-Volga region. However, humus accumul ted by annual crops during their growth does not compensate for that part of the humus which mineralizes during the time from the first to th second sowing. This is due to the fact that annual crops, as a rule, have a wider ratio betwe the tops and roots than do perennial herb mixtures, and have a lesser influence on the increa in the content of organic remains in soil.

2. The value of annual predecessor crops increases with an increase in root residues in the soil after they die off.

3. The highest yield of spring wheat was obtained after perennial and annual herb-legume mixtures. The latter is probably associated no only with the amount of plant residues in the soi but also with the increase of nitrogen by the leguminous component.

4. When growing annual crops, the structural properties of soil worsen noticeably only in the upper portion (0.10 cm) of the plowed layer; in the lower portion (10-25 cm) and especially i the sub-plowed layer (25-40 cm), the content of

mall water-stable aggregates even increases lightly.

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METHODS

METHOD OF PREPARING SOIL, SOIL MATERIAL, RIVER SUSPENSION, AND MARINE SEDIMENTS FOR MINERALOGICAL ANALYSIS

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Soils, soil materials, and similar substances are polydisperse and polymineral systems, i. e., they consist of particles of varying sizes and of several minerals. In addition, they contain organic and mineral amorphous substances (SiO_2, R_2O_3, allophanes) and sometimes soluble and only slightly soluble salts. Later when we speak of soils we will also include clays, soil materials, marine sediments, and river suspensions.

The most accurate and clear concept of the mineral composition of soil can be obtained using a complex of methods: immersion, X-ray, thermal, electron-microscope and others. In a number of cases it is also desirable to determine the humus content, the total chemical composition of the <0.001 mm diameter fraction, maximum hygroscopicity, and the cation adsorption capacity. The latter three analyses not only have their individual significance, but assist in the correct interpretation of the results of mineralogical analysis.

However, it would be wrong to assume that all the foregoing methods must always be used. For instance, in order to detect coarse-grained quartz, it is sufficient to examine the sample under the microscope and determine the refraction index. To determine the presence of highly disperse quartz, it is sufficient to make an X-ray photograph. To determine goethite in soil the thermal method must be used, and iron soluble in the extracts.

To determine the total mineral composition of soil, or of its finely disperse portion, one must make complicated and time-consuming preparation and, first of all, separate the <0.001 mm diameter particles from the >0.001 mm diameter particles. Further we will call the first fraction fine or clay, and the second, coarse.

The separation of the fine from the coarse fraction has several purposes. First, it is necessary because the coarse fraction is studied by the immersion method, while the fine fraction is studied by the X-ray, thermal, and electron microscope methods. In exceptional cases, these methods of separation are reversed.

As a result of practical experience and special investigations (3) we concluded that the <0.001 mm diameter particles or <0.002 mm diameter particles must be taken for X-ray and thermal studies, as is usually done by a number of foreign investigators.

The necessity of separating the <0.001 mm diameter fraction is dictated by the fact that it contains little quartz and other primary minerals, intefere with the determination of secondary, especially clay minerals in the foregoing methods. In addition, in the method accepted in the USSR for the particle-size analysis of soils (5), and <0.001 mm diameter fraction is determined, which permits one to correlate these data with mineralogical investigations. The 0.0002-0.0003 mm colloids are more significant for the physicochemical properties of soils, in particular for their adsorption capacity, stickiness, coherence, etc. In order to study the colloids the <0.001 mm diameter fraction must first be separated and then the colloidal particles must be separated from this fraction with a centrifuge. We do not recommend that colloids alone be studied, since a considerable portion of secondary minerals is contained in the pre-colloidal fraction. The study of colloids only, especially when they are not fully extracted, may lead to erroneous conclusions.

The mineralogical composition of >0.001 mm diameter particles is usually studied by the immersion method, but this method is most often used for >0.005 mm diameter particles and even >0.01 mm diameter particles.

Fine and coarse particles are being separated in order to free the latter of secondary mineral films which interfere with the determination of the mineral composition of coarse particles which is concealed by these films. In view of what was said it is especially important to note that the fine and coarse particles are fully separated.

In 1950 we published an article on preparation of soils for mineralogical investigation (2). Sinc then a great wealth of experimental material was obtained and now the accumulated experience can be shared. The method proposed here consists of a combination of the chemical treatment of soils (5) with mechanical treatment (6, 7, 8, 9, 11), as is normally done in a number of methods of preparing soils for particle-size analysis.

Thus, the main problem in soil preparation onsists in peptizing all finely dispersed par-cles and in creating conditions for the separa-on of soil into its component fractions. Be-ore describing the recommended method, let s describe other methods (1, 4, 5).

The most widely used method of peptizing oil consists in saturating it with monovalent ations (usually sodium) after having previous- removed adsorbed cations with acid and eplaced them by hydrogen ions. According to is method, the soil sample is treated with a eak solution of hydrochloric acid (0.1-0.2 N) ntil all carbonates, gypsum, and other salts re removed. As salts are removed exchange-ble bases are replaced by hydrogen and partly y aluminum.

The soil is then washed with water to remove e excess salts and acid, and an alkaline solu-on (NaOH) is added to the sample in an amount pproximately corresponding to the cation adsorp-on capacity. After this the sample is boiled ith 250 ml of water for 1 hour. The <0.001 m diameter fraction is separated and then e coarser fractions. This method is unsuit-ble for a number of soils. According to our ata, full peptization is not achieved in fine-xtured red earths, in chernozems, and, enerally, in well-aggregated soils and in the luvial horizons of podzolic and other soils rich non-silicate sesquioxides. The quantity of e <0.001 mm diameter fraction separated from e soil, prepared by the foregoing method, is %-15% and sometimes 20%-25% (9) less than s actual content. Incomplete peptization may explained by various reasons. For instance, d earths peptize poorly because of the pres-nce of hydrophobic minerals (kaolinite, oethite, and gibbsite) and coagulators — free uminum ions; chernozem is poorly peptized ecause of the aggregation of particles.

In addition to the foregoing disadvantage, it desirable for the mineralogical analysis of e <0.001 mm diameter fraction by the thermal ethod that it contain calcium or hydrogen ions its adsorption complex and not sodium as it curs in the foregoing method. The investiga-ons of a number of authors (10) showed that onovalent cations reduce the high-tempera-re exothermal effect near 900-1000°C in the ermal analysis of soils and clays. There is such reduction when a sample is saturated th hydrogen or calcium. Thus, after parating <0.001 mm diameter fraction from e sample, exchangeable sodium must be placed by hydrogen or calcium before pro-eding with the thermal analysis; in doing is the mineralogical composition will not ange. Of the two cations named (hydrogen d calcium), calcium is preferable, since additional low-temperature endothermal ect appears on saturation with this cation d the thermogram is richer in content. wever, in a number of cases it is more con-nient to work with soil saturated with hydro-n.

Another method of preparing soil consists treating it mechanically by shaking it with ter, boiling, and triturating it once in the ste state (1, 6). In our opinion this method suitable for saline soils, soils containing carbonates, and also for well-structured and aggregated soils: chernozems, yellow earths, red earths, sierozems, and the iron illuvial horizons of various soils. Only part of the clay and colloidal fraction can be separated by the foregoing methods and then only the most hydrophilic: minerals of the montmorillonite group, allophanes, and organic colloids. Hydrophobic minerals and minerals contained in the microaggregates do not separate from the soil and will not be found during the mineralogical analysis of the <0.001 mm diameter fraction. The chemical composition of this fraction will also differ from the actual average composition. In addition, one must keep in mind that the coarse fractions will be covered by films of non-separated colloids, which would interfere with the microscopic investigation.

To simplify the separation of the <0.001 mm diameter fraction, sometimes a small amount is separated — assuming that after two or three decantations an average fraction is obtained according to mineralogical and chemical composition, but this is not true.

For the thermal analysis of soil we recommend that a 2.5-3 g sample and not a smaller (0.1-0.2 g) sample be used, as is allowed in certain special investigations of salts and certain minerals. Soil minerals give small effects so that we insist that larger samples be used. In the opposite case it is difficult and sometimes impossible to interpret the thermograms. It is not beneficial to increase the thermal effects by increasing the sensitivity of the galvanometer.

A third method of preparing soil consists in treating it with sodium hexametaphosphate ($Na_2P_6O_{18}$) (4) or with ammonia (1). This method is widely used abroad and sometimes, but rarely, in the USSR.

The main disadvantage of this method is that salts interfere with thermal as well as X-ray analyses since carbonates are not removed in this case. In addition, a new reagent is introduced (sodium hexametaphosphate). It is almost impossible to determine highly dispersed minerals, including clay minerals, in a saline sample. Further, it must be remembered that the chemical composition of fine fractions will be changed by sodium phosphate and by carbonates. The latter partly peptize, and on decantation enter into the <0.001 mm diameter fraction, i. e., change its quantity.

With such a method of preparation, the clay and colloidal fractions will be saturated with sodium (corresponding to the cation of the added $Na_2P_6O_{18}$ salt), which will be reflected of the thermal curve, as mentioned earlier.

Considering all that was said previously, we recommend the following complex method of preparing soils and other similar materials, which consists of a combination of chemical and mechanical soil treatment. These methods must be combined differently for different soils.

Method and Technique for Preparing Soils and Decanting Various Fractions

1. A sample is tested for its content in

carbonates, gypsum, and soluble salts.

The carbonates are determined by treating the sample with 1-N hydrochloric acid. Effervescing (liberation of CO_2) points to the presence of carbonates in the soil. It must be remembered that not all carbonates react with acid when cold. Thus the test must be performed first cold, and if there is no effervescing the sample must be warmed on a water bath. The presence of sulfates, including gypsum, may be determined with the aid of barium chloride, which produces an insoluble precipitate of barium sulfate in a hydrochloric acid medium.

2. If carbonates or gypsum are found they must be composted first with 1-N hydrochloric acid and then with a weaker acid (0.1-N).

Carbonates are best decomposed, and gypsum dissolved, in a procelain cup (12-15 cm in diameter) or in a large glass. If the reaction of the acid with the carbonates is very violent, it must be weakened by the addition of water. After the carbonates and gypsum are decomposed, the hydrochloric acid and the formed salts are washed away with water 5-6 times by decantation. Washing should not be complete or there will be a great loss of highly dispersed particles. As soon as the soil begins to peptize, the washing of salts and acid is discontinued, and the method must proceed as described in paragraphs 4, 5, etc.

The sample must inevitably be treated with acid to decompose the carbonates which interfere with the X-ray and partly with the thermal analysis.

It is purposeless to peptize carbonates with ammonia together with the soil, since its action is similar to that of sodium metaphosphate.

The fear that the acid would decompose the clay minerals is exaggerated. Special experiments showed that the dissolution of the mineral portion on prolonged washing with 1-N hydrochloric acid does not exceed 0.5%-1.0%, which is considerably less than the inevitable losses and the sensitivity of mineralogical methods. Only in special cases, such as in the study of the mobile forms of sesquioxides, or during the following study of the surface properties of colloids, must acids be avoided, but in this case colloids or clay cannot be fully separated from the soil.

3. The size of the sample depends on the content of the <0.001 mm diameter particles in it. Samples of clay loam soil must be 50 g in order to obtain not less than 10 g of the <0.001 mm diameter fraction: 3 g for thermal analysis; 0.1 g for X-ray analysis; 3 g for total chemical analysis, including the determination of calcium and sodium; 1-2 g for the determination of the cation adsorption capacity of the <0.001 mm diameter fraction; 0.1-0.3 g for electron microscope study; 0.5-1 g for the determination of maximum hygroscopicity; and 1 g for the determination of humus. The foregoing calculations refer to an optimum investigation program. If part of the analyses are not made, it is not necessary to have a 50 g sample. In addition, if one proposes to investigate both the coarse colloidal and the colloida fractions, the sample must be larger.

4. After the carbonates are removed, each sample is transferred with water into battery jars or glass pot jars of 1.0-2.0 liter capacity. It is best to have glass-jars 20 cm high and 10-12 cm wide. In the future these jars will be called jars No. 1. Each jar will have three marks made with a wax pencil: the first, at a height of 3-4 cm from the bottom; the second, 7 cm above the first; and the third, 7 cm above the second. At the same time the sample number and its name are written on each jar. The marks are needed in order to know to which depth the siphon must be immersed during the decantation of the <0.001 mm diameter fractio

In addition to No. 1 jars, No. 2, or receiving jars will be prepared with a capacity slight larger than that of No. 1 jars. The suspension of the <0.001 mm diameter fraction will be decanted into these jars (No. 2). The number and name of the sample are marked on No. 2 jars. Consequently two jars, No. 1 and No. 2, are needed for each sample.

Jars of other sizes can be taken, or instead of one, 2-3 jars can be used. It is important that No. 1 jars be of a large diameter and of sufficient capacity, since the speed of decantation depends on it and, in addition, the optimu suspension concentration of 1% can be maintained, which is especially import during the first days of decantation. It is desirable that 12-15, or given space and vessels, 20-25 samples be decanted simultaneously.

5. Washing of the sample from salts and acid must be continued in the No. 1 jar. To do this, jar No. 1 is brought up to the third mark with distilled water, the sample is stirre with a pestle with a rubber-end and left to settle for 24 hours. If the suspension does not settle during this time, but remains in a suspended state, one must proceed with the decant tion of the <0.001 mm diameter particles and its collection in the receiving jars, as indicated in paragraph 6.

6. Distilled water is added into the No. 1 jar to the last mark, the suspension is stirred, and 24 hours later a siphon is immersed into t suspension and the suspension is siphoned out into the receiving jar. The depth to which the siphon is immersed depends on the temperatur and particle density. However, in view of the fact that the particle density depends on its mineralogical composition, which is unknown in the sample studied, it is very difficult to give the exact depth. In the table given in the book of N. A. Kachinskiy (5), it is recommende that the siphon be immersed to a depth of 7 cm at a temperature of 20°C. Taking into account that at the beginning of decantation the concentration of the suspension is higher than at the end, we recommend, for the sake of caution, that the siphon be immersed to a depth of 6-6. cm at the beginning of decantation and to 7 cm at the end. Such caution is necessary in order not to remove the coarser particles with the siphon. The depth of 7 cm is conditional, since it is set without considering the mineralo cal composition of the soil and the shape of the particles, while it is known that they determin

ieir fall velocity. We determine the mineralogi- al composition and the shape of the particles nly at the end of the investigations.

It should also be noted that the particle ensity of the suspension changes: at the eginning of decantation primarily hydrophilic articles separate, i. e., easily peptized articles, while at the end more hydrophobic articles separate. It is obvious that the article density of hydrophilic and hydrophobic articles would differ. From the foregoing it s clear why we consider the depth of immer- ion of the siphon as conditional.

After the suspension is decanted, a new por- on of water is added to the last mark, the hole is stirred with a rubber-tipped pestle, nd after 24 hours the suspension is poured gain into a new receiving jar. Each sample s treated the same way. If for any reason e suspenion cannot be poured off daily, it an be poured off every 48 hours, but in this ase the siphon must be immersed to a depth 13 cm at the beginning of decantation and to 4 cm at the end.

After each siphoning the siphon must be insed with water and then immersed in the ext jar. After washing, the siphon should ot be entirely emptied of the suspension, it be transferred to a glass of water and e water passed through it and poured into the ame glass in which the suspension is collected. he siphon is described at the end of the arti- e. The suspension is decanted until it be- omes clear. After this the rest of the soil is ried on a water bath and ground in the state of moist paste for 20 minutes with a rubber estle in a porcelain cup. The ground sample transferred into the No. 1 jar where decanta- on continues.

7. Two to three drops of concentrated drochloric acid are added to the receiving r No. 2 for the flocculation and settling the suspension. When adding acid to the spension the pH drops to 3-4 according to ir measurements, so that one should not ar that the minerals will be decomposed. In- ead of acid one may use $CaCl_2$ as a floccula- r. In this case it must be remembered that lcium will be added into the adsorption com- ex and $CaCl_2$ will accumulate in the solution, hich must be washed out before proceeding ith the mineralogical analysis of the <0.001 m diameter fraction. If one proposes to ake a total chemical analysis, it must be oted that calcium will be present on the adsorp- on complex. Flocculation usually takes place ter 2-3 hours, and sometimes after a day. is not possible to flocculate the most highly spersed and hydrophobic colloids. If there e many such colloids, a centrifuge must be ed for settling.

After the suspension has flocculated and ttled, the liquid above the settled portion ust be removed and the receiving jar be eed for the next portion of the suspension. e new portion of the suspension is flocculated the same way (with hydrochloric acid or cal- um chloride).

8. If the soil is rich in sesquioxides (laterites, red earths, yellow earths, and the ortstein horizons of other soils), peptization does not occur after washing, or occurs only partially. In order to peptize such samples, distilled water should be added to jar No. 1, thoroughly mixed, and decanted after the soil has settled. Such an operation must be repeated 5-10 times. Washing removes the flocculating ions (partly aluminum ions which are present in the soil). After partial peptization has occurred, several drops of ammonia must be added to the soil. If peptization does not occur in this case, the sample must be transferred from the vessel to a porcelain cup, dried to the paste state, triturated for 20 minutes with a rubber-tipped pestle together with several drops of ammonia, and transferred again into jar No. 1, filled with water and mixed. After decanting the suspension 10 or 15 times, the sample must be transferred once again into a cup, dried in a water bath, triturated again with ammonia in a paste state and again subjected to decantation. Peptization cannot be achieved without triturating a second time and decanting the clay fraction. Later the adsorbed ammonia will be replaced by hydrogen, since the suspension is flocculated with acid.

9. If the soil is not enriched with sesquioxides, but contains a large amount of humus and has a good structure, water is added to the sample until it is in the paste form, then it is triturated with a rubber-tipped pestle in a porcelain cup for 20 minutes and transferred into jar No. 1 for decantation. However, only partial peptization of the most hydrophilic colloids and clay is achieved by triturating only once.

To achieve full peptization, the sample is transferred from jar No. 1 into a porcelain cup after the suspension has been partially decanted until it became clear, dried to the paste state, triturated for 20 minutes, and transferred to jar No. 1 to resume decantation. As soon as the suspension becomes clear again, drying and triturating are repeated, and decantation resumed again. According to our experience and to investigations by Shurygina and Nad' (6, 9), structured chernozems require a twofold and sometimes a threefold repetition of the foregoing procedure. We find that a single triturating is insufficient for such materials. One may be easily convinced of this by decanting the <0.001 mm diameter particles from chernozem, red earths, kaolinite clays, and similar materials. A single triturating is sometimes enough for coarse and structureless soils.

10. When the decantation of the <0.001 mm diameter fraction is completed, it is washed with water to remove hydrochloric acid or calcium chloride (depending on what was used for flocculation), and then dried in a water bath. The completion of decantation is determined from the absence of chloride ions in the wash water (reaction with silver nitrate in the presence of nitric acid) and from the peptization of the colloids. If peptization is considerable, washing must be stopped in spite of the presence of chloride ions, to avoid the loss of colloids.

It is very useful to verify again whether the <0.001 mm diameter fraction contains carbonates (sample with HCl) after it has been dried. A small amount of carbonates does not interfere with analysis, but a content of more than 1% interferes with X-ray and thermal analyses. If no carbonates are found, the <0.001 diameter fraction is dried on a water bath, weighed, and subjected to mineralogical and other analyses.

The soil must be taken as a whole for electron microscope investigation, and shaken with water containing a small amount of ammonia. After being properly diluted, the colloids and clay suspended in the water are placed on a film specimen holder and examined under the electron microscope. This does not exclude the electron microscope investigation of the <0.001 mm diameter fraction, as described previously.

According to our data and those found in the literature, the strong and prolonged triturating of a sample in the dry state leads to the crushing of the crystals of secondary minerals, while triturating in a moist state has no destructive effect on the minerals.

If one proposes to study colloids (0.0002-0.0003 mm diameter particles), they must be separated from the <0.001 mm diameter fraction with a centrifuge. We consider it useless to separate the colloids by decantation in vessels, as it is done for <0.001 mm particles, since the slightest change in temperature and the slightest mechanical vibration result in the intermixing of the suspension so that there would be no correspondence between the settling time of the colloids and their size.

11. After the <0.001 mm diameter particles are decanted, the 0.001-0.005 mm diameter particles are decanted, using the same jars and the same suspension flocculator. In order to do this new marks are made on jar No. 1 at a height of 10-20 cm from the first. After letting the suspension settle for 1 hour and 20 minutes (at 20°C), the siphon is immersed to a depth of 10 cm and it is poured off into the receiving jar. Water is added and siphoned out again from 10 cm depth, 1 hour and 20 minutes later at a temperature of 20°C (the operation is repeated until all the <0.005 mm diameter particles are decanted). The suspension is flocculated, washed free from the flocculator, and dried the same way as it is done during the decantation of <0.001 mm diameter particles. After the suspension has dried on a water bath it is weighed. This fraction is used to characterize the particle-size composition of soils, and sometimes for the study of the mineralogical composition by the thermal and microscopic methods.

12. In order to decant the 0.01-0.005 mm diameter particles, the siphon is immersed to a depth of 10 cm and decanted 18 minutes and 39 seconds later (at a temperature of 20°C).

13. The coarse fractions remaining in jar No. 1 are passed through a sieve with openings 0.25 mm and 0.1 mm. The 0.1-0.01 mm diameter fraction will pass through both sieves, while the particles >0.25 mm diameter and 0.1 mm diameter will remain on the sieve. These fractions are dried on a water bath and weighed.

14. In order to calculate the content of particles of various sizes in the sample, the weights of all dried fractions are added, while the content of each fraction is related to this weight in percent of the carbonate-free sample. The data obtained are entered in a particle-size (dispersion) table. Thus, by preparing a sample for mineralogical analysis one obtains at the same time data on the particle-size distribution of the sample. The loss is determined by the difference between the air-dry sample, taken for analysis, and the sum of the weights of dried fractions after the analysis. Losses usuall reach 6%-7%.

15. Coarse fractions (>0.001 mm diameter) are separated in a centrifuge into new fractions, differing in particle density, and the minerals in them are determined under a polarizing microscope.

16. To prepare soils for mineralogical analysis requires 2 months for 12-15 samples, working 2 hours a day. Sometimes there are samples that are difficult to decant and require more time.

17. Construction of the siphon. The siphon is constructed from a glass tube 1-1.5 cm in diameter, bent into two arms of differing length The distance between the arms is 20-25 cm. The length of the short arm is 20 cm and that of the long arm, 20 cm. The end of the short arm must be welded and the portion above it, 3-5 mm above the welded joint must have 3-4 openings of a size of 1-2 mm, directed at an upward angle. The openings are made so that during decantation the suspensed particles will not be siphoned out. A rubber tube, 40 cm long, is connected to the open end of the long arm of the siphon. With this tube the suspension is siphoned from the vessel for filling the siphon.

Conclusions

1. For the peptization of soil it is recommended that it be subjected to chemical treatment and to triturating in a moist state. Variou methods of peptization and decantation of the colloidal and clay fractions must be used, depending on the properties of the soil.

2. Carbonates and gypsum must be removed from soils containing these salts, since they interfere with X-ray, thermal, and other analyses.

3. Flocculators (aluminum ions) must be washed from red earths, yellow earths, and similar materials and then these materials must be triturated 2 or 3 times.

4. If the soils have a stable structure (chernozems), they must be triturated 2 or 3 times in the paste state.

5. In order to prepare the clay fraction for thermal analysis it is necessary that it contain hydrogen or calcium in its adsorption complex.

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A METHOD OF STUDYING THE QUALITATIVE COMPOSITION OF ORGANIC MATTER IN SOIL SOLUTIONS

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Until recently the attention of Soviet and foreign investigators was focused largely on the nature and properties of the principal groups of humus substances — the humic and fulvic acids. However, individual organic compounds are undoubtedly significant in soil processes. Formed during the decomposition of plant and animal residues, and entering the soil with root secretions and fertilizers, many of these substances readily pass into solutions and perform a great variety of functions. They are involved in the decomposition of the mineral part of soil, in structure formation, and in the creation of organo-mineral complexes.

Individual compounds are highly important sources of nutrients for plants. Many of them stimulate the growth and development of plants.

A study of the qualitative composition of organic matter in water extracts, and in solutions extracted from soil, has been hindered by the lack of convenient methods, and soil scientists have been confined chiefly to determining the total content of organic carbon.

Now that new research techniques such as chromatography, electrophoresis, etc., have been devised, it is possible to elucidate the qualitative composition of these substances.

This report presents the results of using paper chromatography to determine the composition of organic matter in solutions from various peat soils.

Experimental Part

The objects investigated were samples of peat obtained from the Central Peat Experimental Station: 1) wood-reed lowland (Meshchera lowland); 2) hypo-lowland (Yakhroma River floodplain); and 3) pine-cotton grass, upland (Shatura rayon, Moscow Oblast').

The solutions were obtained by K. V. D'yakonova by squeezing the peat in an oil press under a pressure of 150 kg/1 cm^2 and bringing it to complete transparency by centrifugation and passing through a Chamberlain filter.

The total organic carbon content, according to Dyakonova, ranged from 0.005%-0.01%.

In all likelihood water-soluble humus substances were present, if only in very low concentrations, in the resultant solutions. The amount in the solution from upland peat, judging by the brown color, was somewhat greater than in solutions from lowland peat with a light-brown color.

We used the chromatography method in solutions to determine the composition of low molecular organic acids, aromatic substances, and amino acids.

Despite the considerable sensitivity of the method, we had to work with highly concentrat solutions owing to their low content of organic matter. The solutions were thickened in a vac at 40°C or under currents of air.

Determination of Organic Acids.

Organic acids were extracted from 100 ml o solution acidified with sulfuric acid by 27 hour of extraction with ethyl ether in an extractor for liquids. The underlying principle of the apparatus is described in the manual of Belozerskiy and Proskuryakov (1).

Upon termination of extraction, 1 ml of distilled water was added to the receiving flask after which the ether was distilled. The water residue was passed through filter paper 5-5.5 cm in diameter. The flask was rinsed with a little water (about 1 ml) poured several times on the same filter. The filtrate with the wash water was then air dried in a porcelain cup with a light current of air at a temperature of about 45°C, and the residue dissolved in a milliliter of distilled water. We thus obtained an extract concentrated one hundredfold and placed it on a chromatogram in 100-200μl amounts with a micropipette.

The organic acids were fractionated on slow filter paper, brand "M" manufactured by the Volodarskiy factory in Leningrad, for 40 hours by n-butanol saturated with formic acid and water, the components being in the ratio of 18:2:9 (7). The chromatograms were developed with a 0.04% alcohol solution of a bron cresol green indicator whose pH was brought u to about 7.5 by 0.1 n alkali (color of solution —

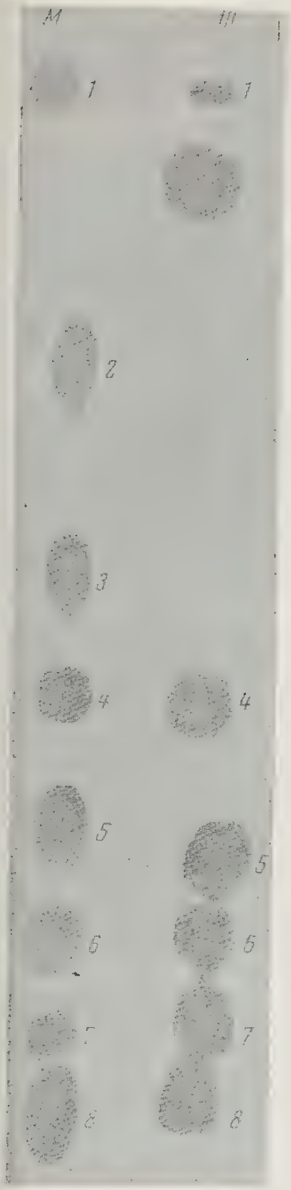

Fig. 1.

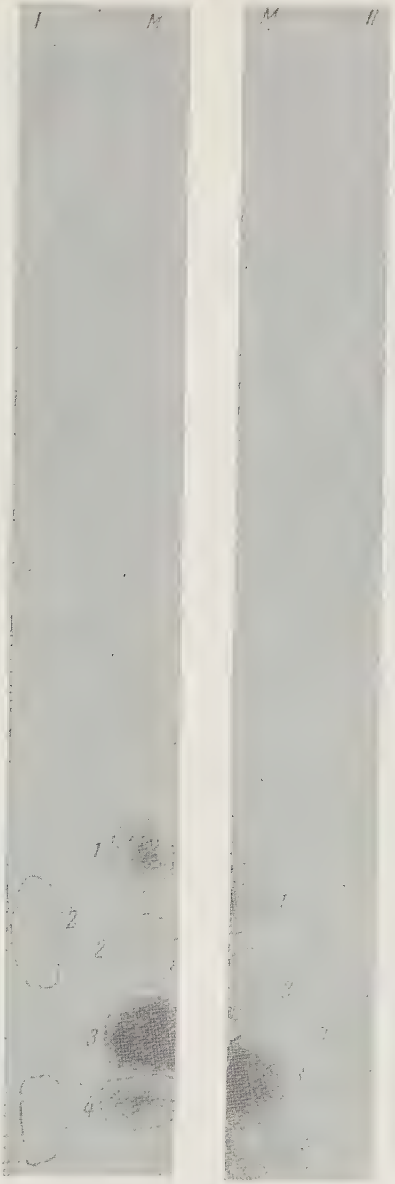

Fig. 2.

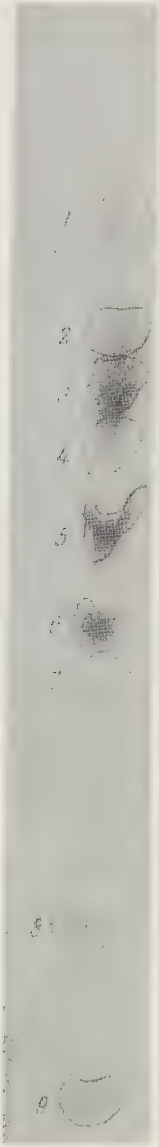

Fig. 3.

Fig. 1. - Chromatogram of organic acids found in a solution from upland peat.
III - solution from upland peat; M - metchiki: 1 - oxalic; 2 - tartaric; 3 - citric; 4 - malic; 5 - lactic; 6 - succinic; 7 - glutaric; 7 - adipic.

Fig. 2. - Chromatograms of substances of aromatic nature found in solutions from lowland peat.
I - solution from wood-reed peat. II - from hypo peat. M - metchiki: 1 - pyrogallol; 2 - protocatechnic acids; 3 - pyrocatechin; 4 - salicylic acid.

Fig. 3. - Chromatogram of the amino acid composition of the hydrolyzate of a solution from upland peat.
1 - lysine; 2 - asparaginic acid; 3 - glycocoll; 4 - glutaminic acid; 5 - threonine; 6 - alanine; 7 - proline; 8 - valine; 9 - phenylalanine.

nse blue).

he clearest results were obtained by chromatographing a solution from upland peat. The spots of organic acids thus revealed corresponded in location on the chromatogram to oxalic, malic, lactic, succinic, glutaric, and adipic acids (Fig. 1).

A qualitative reaction with naphthoresorcine and concentrated phosphoric acid in the solutions investigated revealed the presence of uronic acids.

Determination of Substances of Aromatic Nature.

To extract substances of aromatic nature, the solutions were condensed in a vacuum at 40°C, 40-50 times after which small portions (1-2 ml) were processed once or twice with ether in tightly corked test tubes. The resultant ether extracts were evaporated under a cold stream of air current and applied to the chromatogram in batches of about 50-150 μ1.

The aromatic substances were fractionated on slow filter paper (brand "M") for 24 hours in a mixture of n-butanol, glacial acetic acid, and water in a ratio of 40:12:29 (5). Two solutions were used in succession to develop the chromatograms: 1) a mixture of 25 ml of 0.3 solution of sulfanilic acid in 8% HCl and 1.5 ml of 5% solution of $NaNO_2$ prepared just before use, and 2) a 20% solution of Na_2CO_3 (8).

As a result of chromatography solutions from lowland peat revealed the presence of protocatechnic acid (in the case of wood-reed peat, Fig. 2, II) and pyrocatechin (solution of hypo peat, Fig. 2, II).

No individual aromatic compounds appeared in the dark solution from upland peat. They may be present here in more complex forms (in the composition of molecules of humus substances).

Determination of Amino Acids.

To determine the composition of amino acids, the solutions were condensed in a vacuum 40-50 times and then chromatographed both directly after condensing and after hydrolysis with 6 n HCl at 105°C for 20 hours.

In the first instance a small amount (1 ml) of condensed solution was air dried by a current of air at 40-45°C and the residue dissolved in 10% isopropanol. Some 200-300 μl of the resultant alcohol solution was applied to the chromatogram.

In the second instance the necessary amount of concentrated HCl was added to a given quantity (3 ml) of condensed solution in such a way that the acid concentration in the final volume was 6 n. The solutions were then hydrolyzed for 20 hours in sealed glass ampoules at 105°C. The hydrolyzates were purified and prepared for chromatography by the method that we described in detail in an earlier paper (6). The solvent for fractionating the amino acids was the organic phase of a mixture of n-butanol, glacial acetic acid, and water (4:1:5); the developers were a 0.4% solution of ninhydrine in butanol or an alcohol solution of isatin (3, 4). The exposure time of the chromatograms was 40 hours and then 24 hours more after drying.

The results showed that the maximum amount of free amino acids is present in solutions from lowland peat (hypo and wood-reed). Lys histidine, arginine, and asparaginic acid were found in both. The solution of hypo peat contained, in addition, glycocoll, glutaminic acid threonine, and alanine.

The intensely colored solution obtained fro upland peat failed to reveal any free amino aci except glycocoll. However, 9 amino acids we found after hydrolysis: lysine, asparaginic, and glutaminic acids, glycocoll, threonine, alanine, porline, valine, and phenylalanine (Fig. 3). This suggests the likelihood that the amino acids in a solution from upland peat, li the aromatic compounds, form part of the hum substances.

Our findings indicate that solutions from lowland and upland peat contain a variety of individual organic compounds: low molecular organic acids, aromatic substances like the polyphenols, amino acids, and uronic acids.

Further work will have to be done to impro the chromatographic methods of studying individual organic substances in solutions befor they can be determined quantitatively.

Among the techniques of quantitative chromatography recommended in the literature th following merit attention: visual comparison spots appearing on a chromatogram following application of different amounts of the solution under study, or of a solution with known conte measurement of intensity of color of spots wit a densimeter; measurement of area of spots; spectrographic methods; extraction of substances from a chromatogram using a suitabl solvent, followed by determination of the amo by the most convenient method available (2, 9) The choice of method is dictated by the requir accuracy of determinations, properties of the substances being studied, and the purpose of research.

In this connection it would be interesting to test the methods of qualitative and quantitativ chromatography as applied to the study of solutions from mineral soils, ground and surface water, and to investigations bearing on the problem of purifying water reservoirs.

Conclusions

1. The method of paper chromatography reveals the presence of low molecular organic acids, aromatic substances like the polypheno amino acids, and uronic acids in solutions bo from lowland and from upland peat. In addition, they contain very low concentrations of purely humus substances.

2. Judging by the composition and nature the organic compounds present in the solution they may well be involved in a number of processes (decomposition of minerals, creation o organic mineral complexes, plant nutrition, stimulation of plant growth).

3. Additional work will have to be done to develop methods of studying individual organi substances before they can be determined

antitatively.

These methods may be tested for investiga-
n of solutions from mineral soils, water res-
voirs, ground and surface water.

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SPRING EROSION OF SOIL ON THE KLIN-DMITROV RIDGE

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We made observations on the erosion of sod-strongly podzolic and medium podzolic clay loam soils on clay loam deposits during the melting of snow in spring. The site was the Kalinin kolkhoz located in Dmitrov rayon, Moscow Oblast'. The land is in the central part of the Klin-Dmitrov ridge which, according to Sobolev (3), is in a region threatened with erosion. Erosion caused by melting snow and heavy rains is fairly advanced here.

The terrain of the region is very rugged, being intersected by deep river valleys and ravines. There are many short slopes of different forms. The level watershed areas are comparatively small.

Spring runoff is largely affected by the distribution of snow on the slopes with different exposures. Observations have shown that snow is unevenly distributed on the slopes. This is caused by winter winds carrying it away from unprotected places. Southwesterly winds are predominant in the region. On the unexposed slopes (northern, eastern) the wind velocity is reduced owing to the obstacle provided by the watershed part, so that accumulations of snow are fairly substantial here. On the windward slopes, however, the snow is blown off and carried to the protected slopes. Unevenness of distribution depends on exposure, not on elements of the slope (Table 1).

Table 1 shows that there is a certain pattern to snow distribution. Until a field is completely clear, the snow thickness and moisture content increase from top to bottom of the slop The thickness of the snow is much less on the slopes with eastern exposure than on those faci north. When the snow melts, the water on the slopes with eastern exposure decreases more rapidly than on those facing north.

Freezing of soil is closely connected with th presence of snow. In the fall of 1957 snow continued to lie on unfrozen soil and prevented it from freezing any further. On the slope with eastern exposure the depth of soil freezing ear in March was 32-40 cm, but ranged from 30-5 cm on the slope with northern exposure. Shallower freezing (30 cm) was noted on the lower part of the slope where the snow depth (due to wind) was 52.6 cm. The lower part of one of t slopes facing north with snow depth of 78.1 cm was observed on March 5, 1958 to have unfroz soil. Consequently, heavy snow not only prevents the soil from freezing deeply, but also greatly affects thawing. Deep freezing and tha ing of soil varies with the character of the lanc use. Periodic (from December 25, 1958 to April 1959) determinations of freezing depth ar thawing and thickness of snow were made on la with winter wheat stubble, on a late-fall plowe field (slope with eastern exposure), and in the forest (Fig. 1). The depth to which the soil wa frozen was ascertained with an augur and crow bar from the presence of ice crystals (a magni ing glass was used here), and with a sketch of the profile of the frozen soil. It will be noted that before the field was freed from snow, the

Table 1

Changes in snow depth, in cm, and moisture contents, in ml, in relation to slope exposure
Late-fall plowed field

Exposure	Condition of soil surface on slopes. Direction plowing	Element of slope	March 5		March 14		April 7	
			snow depth	moisture content	snow depth	moisture content	snow depth	moisture content
eastern	across the slope	top	33,2	76,4	38,0	81,3	17,1	41,0
		bottom	42,2	97,0	45,5	100,0	30,3	72,0
northern	along the slope	top	39,5	86,9	38,5	84,7	23,2	58,0
		bottom	52,6	115,7	67,5	148,5	50,6	129,0

Note: Comma represents decimal point.

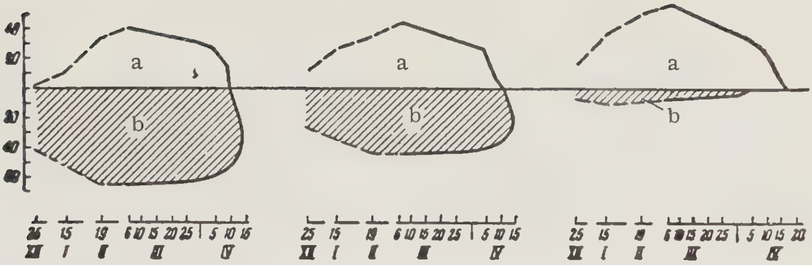

Fig. 1 - Snow and freezing of soil.
A - snow; B - frozen soil.

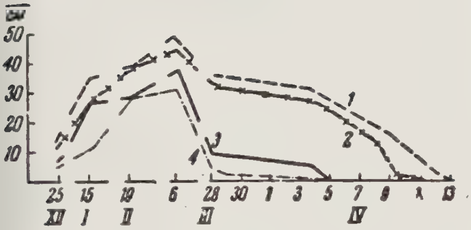

Fig. 2 - Changes in snow depth on slopes with different exposures. Winter wheat stubble.

1 - northern exposure; 2 - eastern; 3 - western; 4 - southern.

umber of ice layers and accumulations of crysals in frozen soil decreased with depth. The reatest depth to which the open field froze was oted at the end of February, while the maximum hickness of the snow occurred in March. The oil froze to a greater depth on the late-fall lowed field than on the stubble. Deep freezing f soil on the former was attributable to the ength of time the ridges of the plowland reained without snow and to the greater area subected to fall plowing. In the forest, owing to he litter and large amount of snow, the soil only roze to 9 cm; the maximum occurred in the iddle of January, and not at the end of Februry as in the case of the open field, because the now was already deep in February, thus preenting the soil from freezing any further. Our bservations of thawing in the field confirmed achinskiy's (1). Kachinskiy noted that with deep freezing of soil, thawing takes place only from below until the surface is freed from snow. After the snow disappears, thawing also takes place from above, but much more quickly. However, in the forest where the snow is deeper and the litter "heats" the soil, thawing takes place long before the snow disappears.

The formation and destructive activity of the runoff also varies with the way the snow melts on the different slopes. The rate of melting from slope exposure has a great bearing on spring erosion. For example, melt water rushing down the southern slope with the underlying watershed still covered with snow easily loosens and carries away the shallow thawed "thin" soil, especially if it has no protective vegetation. We selected a hill about 14 ha in area to determine the nature of melting of snow on slopes with different exposures. The winter wheat stubble was left all over the area for the winter. Three slopes—eastern, northern, and western—are convex and with virtually identical steepness, while the slope facing west is straight and less steep. The depth of the snow was measured every month beginning with December and every day after it began to melt (Fig. 2). The uneven distribution of the snow had a marked effect on the way it melted. Figure 2 shows that the slope with southern exposure lost its snow 6 days sooner than the northern slope; the southern slope lost its snow 1 day before the western slope. It will be noted that the snow melts almost at the same time on elements of the slopes facing south and west, with a slight lag on the upper parts of the slopes. The snow not only melts rapidly on these slopes, but the thaw water frequently flows over the thawing soil which becomes saturated and

Table 2

Erosion of sod-podzolic clay loam on slopes with various exposures. Plowed field. Winter wheat stubble (distance from watershed - 150 m)

Slope exposure	Direction of crop rows	Shape of slope	Steepness, degrees	Erosion, m³/ha
eastern	along the slope	convex	5°30′—10	1,33
western		"	5—8	2,27
southern	across the slope	straight	4—6	1,70
		convex	7—10	None

Note: Comma represents decimal point.

Table 3

Spring erosion of soil in relation to the kind of cultivation.
Slope with northern exposure.

Late-fall plowed field	Distance, in m, from the watershed divide	100	150	200	250
Plowing across the slope	Steepness of the slope, degrees	4	7	6	3°30′
	Erosion, m³/ha	2,46	6,50	9,16	7,55
	Distance, in m, from the watershed divide	100.	150	200	250
Field under potatoes	Steepness of the slope, degrees	4	3	6	4
Plowing along slope	Erosion, m³/ha	4,20	5,52	17,37	17,20

Note: Comma represents decimal point.

easily eroded. On the slopes opposite (northern and eastern exposures), first the upper parts are freed from snow, then the middle, and finally, the lower parts. Thawing of the soil takes place in the same order. Here the melt water coming from the top of the slope flows onto soil still covered with snow and, as a rule, frozen. This soil is not subjected to erosion (or only slightly so) until the snow disappears, but as soon as the snow on the bottom of the slope melts, the amount of water flowing downhill reaches a minimum. That is why spring erosion on the northern and eastern slopes, despite their greater depth of snow, is less than on the southern and western slopes (Table 2). At the end of April, after the snow melted, we determined the extent of erosion on all the slopes using the method of calculating the size of gulli worked out by Sobolev (3).

Erosion on the slopes is generally slight owi to the protective action of the winter wheat stub Another reason for the slight erosion is that the watershed part of the hill has sandy soil which readily absorbs moisture, so that the actual length of the line of the runoff is less than the

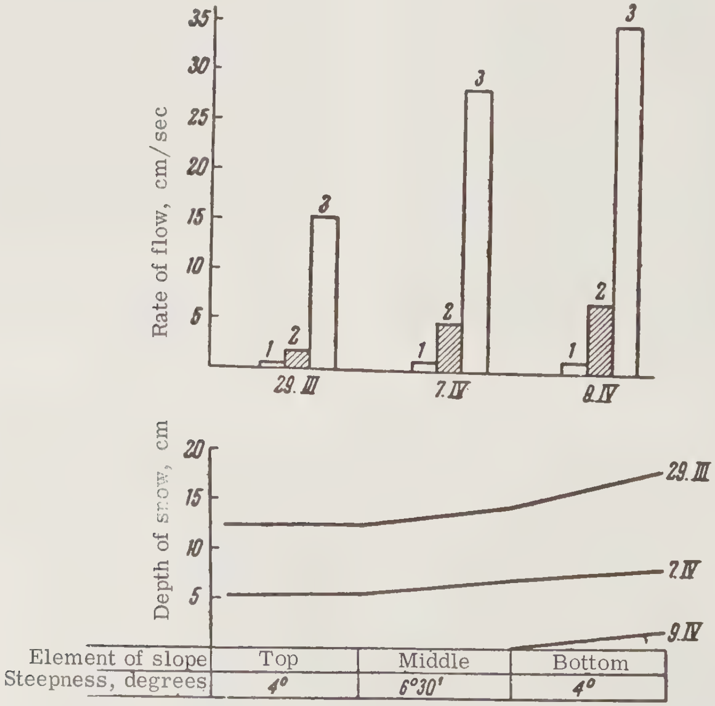

Fig. 3 - Depth of snow and rate of surface runoff.
1 - 29 March; 2 - 7 April; 3 - 9 April.

istance from the top of the hill. Nevertheless, he difference in degree of erosion on the slopes s marked. Although the depth of snow on the lope with the eastern exposure was greater han on that with the western exposure, there vas less erosion because the rate of melting on he western slope was greater than on the east-rn slope. The nature of the melting, as nentioned previously, also affected the degree f erosion. On the southern slope erosion narkedly increases downhill, although the rows f crops are arranged across the slope, where-s on the northern slope, where the grade is -10°, there is practically no erosion.

The activity of the thaw water, other things eing equal, likewise depends on the alternation f subzero and above-zero air temperatures vhile the snow is melting. If this happens fre-uently, the amount of water in the form of snow radually decreases and in the event of runoff f thaw water, the frozen soil is not washed way. The runoff rate increases with decreas-ng depth of snow. Figure 3 shows that the run-ff of thaw water in the spring of 1959 began Iarch 29 when the average depth of the snow vas 14.6 cm. By April 7 the runoff increased o 5.22 cm/sec. To determine the rate, two arallel trenches were dug into the snow across ne slope (3 meters apart). The thaw water vas stained with a solution of potassium per-nanganate in the upper part of the trench and aught in the lower part. The flow rate of the nitial colored streams was taken for the run-ff rate. When melting was most intense, the ir temperature having risen, only 50% of the lope remained covered with snow. The swift nelting did not result in erosion of the soil, vhich averaged 9.92 m³/ha on the slope. As oon as the melting ceased, we determined the urbidity of the streams on three elements of ne eastern slope by taking samples of thaw vater with suspended particles of soil six mes. The results were as follows: on the up-er part of the slope, 2.20 g/l; on the middle art, 8.69 g/l; and on the lower part, 11.15 g/l f suspended soil particles.

Quite a different picture was observed on nis slope with the same type of soil cultivation all plowing along the slope) in the early spring f 1958 when there were no abrupt temperature hanges. Whereas in 1959 (March 24-29) the emperature was well above zero, in 1958 it did ot rise above 0.2°C and there was no surface unoff of thaw water, which remained mostly in ne snow (ignoring the amount lost by evapora-on). After April 10, owing to a sharp rise in emperature, the snow completely melted in 3- days, forming a heavy runoff that washed way a good deal of soil. The rapid melting kewise showed up in the turbidity of the thaw ater, which averaged 23.2 g/l on the slope. hus, in 1958 erosion caused by thaw water on ne slope with the eastern exposure was three mes greater than in 1959. From the observa-ons of March 14 the water content in the form snow was virtually identical in both instances 959, 72.81 mm, depth of snow, 28.00 cm; 958, 74.88 mm, depth of snow, 31.20 cm). owever, in 1959, owing to sudden thaws and equent changes in air temperature, the water ontent in the form of snow greatly diminished oward the end of March, forming a runoff of naw water. This water, flowing down the slope while snow was present, failed to wash away any appreciable amount of soil.

The effect of melting rate on erosion varies with the character of the land use. On the slope with eastern exposure we determined spring erosion on two adjacent plots (length, steepness, and shape of slope being identical) one of which was newly cleared after stubbing (late-fall plowing, raising of furrow along the slope); another part of the field had the stubble of winter wheat planted along the slope. Calculations showed that spring erosion on the stubble was one-third that on the newly cleared plot which lacked the protection of vegetation. As for deposition of soil particles, the accumulation products on the stubble were too few to be calculated, while in the lower part alongside the plot the alluvial cones could be clearly distinguished.

On the farms located on the Klin-Dmitrov ridge the convenience of using tractors for plowing has generally led to the planting of potatoes along the slope. This helps to intensify erosion by thaw water and heavy rains. After the potatoes are harvested, furrows stretching down the slope serve as canals for collecting thaw water. This is clearly evident from the data in Table 3 which show that the slope where the potatoes were planted and harvested was less steep than on the plot plowed horizontally, yet erosion was much more extensive on the field under the potatoes.

Spring erosion in this region shows up on all the cultivated slopes, but the fields cultivated during fall along slopes tend, other things being equal, to be most affected. The most resistant are the fields with perennial grasses. Lacking the opportunity to check the action of thaw water under completely analogous conditions, we decided to observe erosion after melting of snow on fairly large areas of the kolkhoz pasture lands (Table 4).

Observations were conducted on slopes of convex form about 100 m from the watershed divide. The resultant data testify to the great importance of vegetation in preventing erosion. Vigorously growing winter crops bind the soil firmly with their roots so that it generally offers considerable resistance to the erosive action of thaw water.

Despite the fact that the plot plowed late in the fall is half as steep as the slope with winter wheat, erosion on the field plowed and planted lengthwise late in the fall is double that on the field with winter wheat (9.20 m³/ha versus 4.58 m³/ha). The same ratio is found when comparing data for erosion on slopes with across the slope plowing and rows of crops (2.46 on the late-fall plowed field and 1.41 m³/ha on the field with winter wheat).

Table 4 shows that with almost identical grade of slope the field with winter wheat sown across the slope (grade of 8°) suffers one-third as much erosion in the spring as the field also plowed across the slope late in the fall (grade of 7°). The data plainly reveal the importance of direction of plowing and rows of crops in controlling spring erosion. For example, after planting of winter wheat along the slope, erosion was more than triple that following planting across the slope.

Table 4

Spring erosion of soil on different land use and with different directions of plowing and arrangement of crop rows (distance from the watershed - 100 m)

Land use	Direction of plowing and crop rows	Slope exposure	Steepness of slope, deg.	Erosion, m³/ha
Late-fall plowed field	along the slope	eastern	4	9,20
	across the slope	northern	4	2,46
	along the slope	"	8	13,13
	across the slope	eastern	7	5,28
Winter wheat	along the slope	"	7	4,58
	across the slope	"	8	1,41

Note: Comma represents decimal point.

Erosion on the field plowed in late fall across the slope (grade of 7^0) amounted to 5.28 m³/ha, but when plowed in longitudinal direction it came to 9.20 m³/ha, despite the fact that the slope was less steep (4^0).

S. S. Sobolev (2) notes that inasmuch as the bulk of nutrients in podzolic soils is concentrated in the shallow humus horizon, the development of erosion causes a swift decline in fertility. Hence, preventive measures in this area are extremely important.

Several techniques have been developed to prevent washouts by thaw water in the fall and early spring.

A major role in controlling erosion on the Klin-Dmitrov ridge, which is located in a zone of adequate moisture, is the regulation of melting snow and diversion of thaw water. Regulation of spring melting of snow is effected by blackening, raking, or compacting the snow. An effective and economical method is to make strips across the slope. Since the snow depth is generally greater in the lower portions of the shady slopes, simultaneous removal of snow from the slope and timely execution of suitable agricultural measures require compacting of the snow in the upper strips and blackening in the lower strips. It is best to use strip compacting on the southern and western slopes. As for raking, we feel that it should be done on noncontiguous strips, the gaps being arranged in checkerboard fashion. Of considerable value in checking melting is the use of snow as a mulch in the upper parts of the northern and eastern slopes, and in the lower parts of the southern and western slopes.

Fall agricultural practices should include non-continuous ridging, building of embankment and diversion of thaw water. The most convenient erosion control is the use of the water-regulating and soil-protecting properties of the crops themselves. Well stooled winter crops afford excellent protection from erosion by thaw water if they are planted in rows across the slo The importance of fertilizers in preventing erosion is obvious. Plowing, planting, etc., shoul be done only across the slope if the harmful effects of unregulated surface runoff are to be averted. The steps suggested are well within the capabilities of every kolkhoz in the region, and they will be useful in preventing loss of fertility and in increasing the yield of crops fro every hectare of arable land.

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REEZING AND THAWING OF PEAT SOIL
NDER CONDITIONS PREVAILING IN THE MESHCHERA LOWLAND

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The freezing and thawing regime of peat soils
s a considerable influence on the utilization of
gs. The time of sowing, the harvesting of
at, the duration of the growing period of agri-
ltural crops, etc., depend on the freezing and
awing regime. This is why its study is of
eat practical interest.

This article examines certain little-studied
oblems of the water and thermal regimes of
at soils during the winter-spring period, on
e basis of observational data collected by the
thor at the Zonal Experimental Melioration
ation of Meshchera from 1957-1960.

The investigations were conducted in the
Kal'skoye" lowland bog in the southern part of
e Meshchera lowland at a distance of 30 km
om Ryazan', which was drained in 1953-1954
a network of deep channels. The peat in the
g is alder and birch peat mixed with reed and
dge peat, 3 m thick, and underlain by fine-
ained sand. The degree of decomposition of
ganic matter is 40%-50%, the bulk density of
e peat in the upper 0.5 m is 0.18-0.27, its
ecific gravity is 1.6-1.9, and its porosity is
out 90%. The depth of freezing and thawing
is determined from digging holes and by prob-
g, repeating the measurements 2-16 times.

Meteorological Conditions during the Observation Period

The winter of 1957-1958 was average as far as the temperature regime was concerned, and was characterized by insignificant warm spells in the first half of winter (November—January). Snow fell on frozen soil and did not exceed 7 cm in depth in the first 2 months.

In the winter of 1958-1959 snow also fell on frozen soil, and its depth in November—December exceeded 7 cm only during 4 days. This winter was warm with frequent short warm spells in November, December, January, and March. During the warm spells the snow did not fully disappear from the fields. Positive air temperatures set in on March 25, however, two prolonged cold spells occurred later.

The winter of 1959-1960 was rather severe with short warm spells in February and March. A continuous snow cover formed as late as in December and was deeper during this month (up to 18 cm) than during preceding winters. The winter temperature and snow cover characteristics are given in Table 1 (the temperature data were taken from the Ryazan' Meteorological Station).

Table 1

Brief characterization of winters

Indices	Years		
	1957—1958	1958—1959	1959—1960
Date of onset of persistent negative air temperatures	Nov. 10	Nov. 6	Nov. 8
Duration of freezing period, days	147	146	153
Sum of winter mean daily negative air temperatures	981,5	800,1	1303,5
Same for November—December	258,9	294,7	537,0
Sum of mean daily positive air temperatures in winter	3,8	11,1	3,7
Date of mean air temperature transition through 0°C	April 7	March 25	April 9
Data of end of snow melting in bog	April 12	April 10	April 12
Mean snow depth before snow melting, cm	31,6	47,1	25,4
Mean snow density before snow melting	0,33	0,30	0,37

Note: Comma represents decimal point.

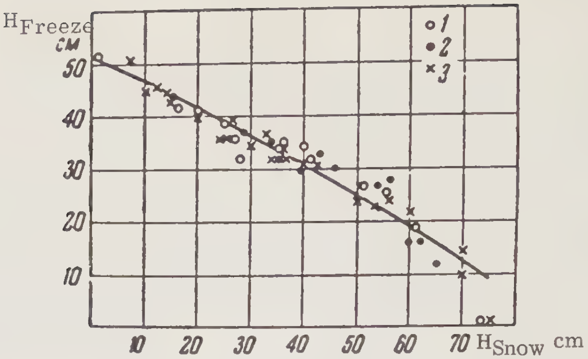

Fig. 1 - Relationship of peat freezing depth to the depth of snow cover and ground-water level.
1 - point 1; 2 - point 2; 3 - point 3.

Freezing of Peat Soils

The freezing depth of peat soils depends on a number of factors: air temperature, snow cover depth and density, time of snow cover formation, vegetation, the nature of soil tillage, ground water depth, etc. The qualitative nature of the influence of most factors on freezing is obvious, but the degree to which they affect freezing under their complex action can be determined only from long-period investigations under various winter conditions.

At present there is a number of formulas for determining the freezing depth of peat in which the depth of freezing is related to the sum of negative air temperatures during the winter period, the average weight of snow cover depth, and the moisture of peat before freezing. If the effects of soil tillage, the utilization of bogs, and other factors are taken into account at all, it is done by means of coefficients, which consider their overall effect only. This is attributable to the fact that there is insufficient material from freezing investigations.

As we know, air temperature and snow cover depth have the main effect on the freezing of peat soils. Vegetation promotes snow retention and increases its depth. The direct warming effect of vegetation on the soil of reclaimed bogs is very small, or nonexistent. Snow cover depth is also affected by microrelief.

Even though snow density has an effect on th depth of freezing, it is difficult to segregate it from the influence of other factors, and it is very small. Snow density distribution curves a similar for various winters, according to our o servations, and snow density during snow surve varies much less than snow depth. Thus, the modular snow cover density coefficient before snow melting (K—ratio between snow density at the point of observation and the average for the area) varied on the average in 5 years from 0.62-1.23, while at the same time the modular snow depth coefficient varied from 0.1-2.4.

Soil tillage also affects freezing depth by changing the microrelief of a field and the struc tural compactness of its upper layers. According to the data of Gusev (3), soil froze to a dept of 37 cm in plowed plots with ground water at a depth of 50-60 cm, while soil in non-plowed plo froze to a depth of 30 cm. According to the dat of Gantimurov and Gordeyeva (1), the average depth of peat freezing in an area which was rototilled, plowed, and rototilled, was 102 cm, while in an area rototilled in three passes, freezing reached a depth of 81 cm.

The depth of ground water from the soil surface has a considerable effect on its freezing depth. It is known from the literature that well drained bogs freeze to a greater depth than non-drained bogs (2, 4), however the degree to whic ground water influences freezing remains unclear. In order to clarify this we investigated the depth of freezing at five points having

Table 2

Ground-water levels, in cm, below the surface for the winter of 1958-1959

Point No.	Observation date			
	Nov. 6	Nov. 19	Feb. 16	Mar. 17
1	223	228	245	245
2	111	126	140	140
3	71	95	100	95
4	60	74	78	82
5	20	35	55	55

Table 3

Relationship of depth of soil freezing on snow depth and ground-water depth

Point No.	Snow depth, cm						
	6	22	35	40	46	50	53
1—3	49	40	34	31	28	24	23
4	—	36	28	25	24	13	11
5	39	30	23	21	15	10	8

Table 4

Variation in freezing depth in different winters depending on snow cover depth vith the same ground-water level (1.0 m)

Years	Snow depth, cm						
	6	22	35	40	46	50	65
957—1958	48	37	27	24	19	16	4
958—1959	49	40	34	31	28	24	15
959—1960	52	45	39	36	32	30	21

erent ground-water tables (Table 2).

The effect of vegetation on freezing depth eliminated by distributing the observation its in fields tilled the same way, in 1958 in otato field, and in 1959 and 1960 in a field ved late in the autumn. As a result, two n factors had an influence on the depth of freezing: the depth of ground water and w cover depth.

Ve may assume that the differences in snow er depth at individual points of the surface flat, open area under similar meteorologi- conditions during the snow accumulation iod are governed only by the microrelief, reby its effect is the same throughout the ter. This is why in measuring simultaneous- he depth of soil freezing and the snow cover h one may obtain the relations between the at each measuring point, and from these rmine the influence of the ground-water h.

The period of greatest interest is that which preceeds snow melting, or the period of the formation of maximum snow storage, as it is called in hydrology. At this time soil freezes to the maximum depth. Our observation is limited to this period, which occurred during the years of observation in the third week of March.

The results of observations in 1959, given in Figure 1 for the observation points 1-3, which are characterized by a deep ground-water table (more than 1.0 m), show that the freezing depth did not depend on the ground-water level, but was almost the same. In this case there was a well-expressed dependence of freezing depth with depth of snow cover. The mean deviation of the points from their average second-degree curve is 2.3 cm, i.e., almost within the limits of accuracy of the measured values.

The effect of the ground-water level on freezing depth is traceable at observation points with a ground-water table higher than 1.0 m, but the dependence of freezing depth on snow cover depth is less pronounced (Table 3).

In 1960 a relation was also found between the freezing depth and snow cover depth with a low ground-water table (the correlation curve was above that for 1959), whereby the freezing depth at point 1 was somewhat greater than at points 2 and 3. With a high ground-water level, the depth of freezing averaged about 19 cm and was almost independent of snow cover depth.

Thus ground water has a noticeable warming effect on the soil, especially when it is located close to the surface. This effect is achieved in two ways: through soil moisture and by the direct transfer of heat to the upper soil layers. As we know, the moisture of the latter depends on the ground-water level: the closer is ground water, the greater is soil moisture. Soil moisture,

Table 5

Water contents in the upper soil layer during the winter of 1959-1960

Indices	Observation Point No.					
	66	19	23	69	39	11
Ground-water depth during the winter, cm	95	110	120	130	160	170
Increase of water contents in 0-30 cm-layer, mm	75,5	37,3	83,9	79,8	56,4	18,0

Note: Comma represents decimal point.

Table 6

Influence of the soil surface state on thawing depth in the spring of 1959

State of soil surface	Observation date								
	Apr. 13	Apr. 14	Apr. 16	Apr. 18	Apr. 20	Apr. 27	Apr. 30	May 4	May 9
Ridge	11,3	12,6	15,3	18,3	19,4	23,6	26,0	31,5	33,5
Flat, harrowed	7,6	9,1	11,8	15,4	18,0	21,3	25,0	28,3	31,1
Furrow	5,8	6,5	9,5	12,4	15,1	17,3	19,4	23,2	25,8
Calculated according to the formula of Pechkurov[6].	7,7	8,8	11,1	13,4	15,1	17,8	20,0	23,8	27,0

Note: Comma represents decimal point.

Table 7

Empirical formulas for determining thawing depth in relation to air temperature sum and state of soil surface

State of soil surface	Formula	Deviation of points from the curve, cm	
		mean arithmetic	mean square
Ridge	$h_0 = 2{,}29\,(\Sigma t)^{0{,}48}$	0,59	0,67
Flat	$h_0 = 1{,}34\,(\Sigma t)^{0{,}57}$	0,44	0,29
Furrow	$h_0 = 0{,}82\,(\Sigma t)^{0{,}62}$	0,74	0,80

Note: Comma represents decimal point.

on the other hand, has a decisive influence on the thermal regime of soil. When the ground-water levels are high, the strongly wetted soils, even though they possess a high thermal conductivity and thus cool more rapidly than drier soils, freeze much less, since in this case more heat is liberated during ice formation. When the ground waters were deep (more than 2.0 m), and moderately deep (1–1.5 m), the total effect of these factors during the years of observation was apparently almost equal so that the freezing depths were similar.

The analysis of observation data for 3 years, analogous to those given in Figure 1, allows us to determine the influence of meteorological conditions on the freezing depth. In doing this we find that with the same snow cover depth the depth of freezing was smaller in the colder winter of 1957-1958 than it was in the warm winter of 1958-1959 (Table 4).

This may be explained first by the effect of frost in the beginning of winter on soil that is unprotected or little protected by snow. Maximum soil freezing intensity is observed in November—December, as recorded in 8 years of observation in the peat industry of the Urals (8). Table 1 shows that the temperature sum for these 2 months in the winter of 1958-1959 was higher than in the preceding winter, while the ratio between the sum of negative temperatures in 2 months and the sum of negative temperatures for the winter varied for the years of observation in the following way: 1958, 0.26; 1959, 0.37; and 1960, 0.41. In our opinion, this relationship may be used to determine the effect of the increased freezing rate in the beginning of winter.

It must be noted that the depth of ground water determines the qualitative characteristics of frozen soil. With more intense drainage, cavities free of ice and peat are always found in the frozen soil layer. The free pores are not eliminated during the process of winter moisture accumulation as a result of the water movement from the lower layer to the freezing front. When the ground waters are close to the surface, the soil becomes saturated with water in winter and represents a monolithic mass, deprived of any pores. In this case moisture very often reaches full moisture capacity and even exceeds it. Such a phenomenon occurs rarely and only in the upper layer when drainage is intense.

The winter accumulation of moisture in the frozen layer is very great. Thus, in 1959 it reached 67.0 mm, 73.3 mm, and 77.1 mm in th upper 30-cm layer at three observation points where the ground water was at a depth of 1.0 m during the winter; with this there was a certai decrease of the moisture contents in the underlying layers. The results of observations in 1960 are given in Table 5 (moisture was measured by the weighing method in each 10-c layer, replicated 4 times).

We must assume that this accumulation resulted from ground water and occurred only in the winter of 1958-1959, probably in small amounts during warm spells. As may be seen from Table 5 there is no relationship of winter moisture accumulation from the ground-water depth, which confirms the results of observati by Sokolovskaya (7).

Thawing of Peat Soils

The thawing of peat soils may proceed both from above and from below. Thawing from below is rare and occurs only in slightly drained peat beds when the ground water is at a depth less than 1.0 m. In this case the entire peat d posit becomes saturated with water in spring a thawing occurs as a result of the heat supplied it. In 1959 the depth of peat thawing from belo was 6-7 cm in an area where the ground-water level was at a depth of 0.5-0.7 m. In well-drained bogs thawing took place only from abo

Thawing from above begins after the snow disappears. Its intensity depends on the state the soil surface (Table 6), and is determined e clusively by air temperature.

There was no acceleration of thawing in we drained bogs as compared to less well-draine bogs (which is mentioned in the literature), ev though we made our investigations at observat points with varying ground-water levels.

The relationship of the depth of thawing of soil to the sum of mean daily positive air tem tures during the thawing period was well expr all types of soil surface in all 4 years of servation (Table 7). According to our 5-year servations, the snow contents in the field be- e snow melting under conditions prevailing in Meshchera lowland were 91-142 mm, while mean melting intensity was 6.1 mm for each gree of positive mean daily air temperature a height of 2.0 m, i.e., soil thawing begins en the temperature sum reaches 15-23°C.

The foregoing relations differ from the mula $h_0 = 1.58 (\Sigma t)^{0.50}$, derived by Pechkurov drained and plowed bogs in the Belorussian R (6). The depths of freezing calculated by s formula (Table 6) are close to the values ained under our conditions for furrows 20-30 deep. It must be noted that during the years observation the thawing of the peat deposit en frozen to a maximum depth of 30-40 cm led in the second or third weeks of May.

A great role in the thawing of soil is played meltwater which accumulates in the depressed crorelief features and runs off along the sur- e. The soil thaws earlier in puddles and wing is uneven. Thus, in a puddle filled with -20 cm of water in a winter rye field, soil ich was frozen to a depth of 30 cm, thawed to epth of 9-10 cm on the sixth day, while the rounding soil thawed to a depth of 5 cm. At same time, 10 thawed funnels averaging 32 in diameter formed in another puddle at a tance of 78 m.

Infiltration of Meltwater

Observations showed that frozen peat soils permeable to meltwater. As indirect icator of this is the fact that the ground water gins to rise in the bog at the beginning of snow lting.

There are the following three ways in which ltwater infiltrates the soil: 1) through fun- s which form as the soil thaws, 2) through wed funnels in the soil, and 3) through the ire soil surface.

The main way in which meltwater infiltrates t soil is the first. There are always micro- pressions, small holes, etc., at the soil sur- e, in which the soil freezes little because of warming effect of deep snow. Water col- ts in these depressions in the first days of w melting and accelerates thawing. The er enlarges the fissures and passages in the llow frozen layer and transforms them into nels. The probability of the formation of h funnels and their number depend primarily microrelief and on the slope of the soil sur- e. Such funnels are clearly visible in fur- s during the last days of snow melting and in first days after the snow has disappeared. e funnels are usually about 10 cm in diameter. eir number increases as the ground-water el rises, since with shallow drainage they resent almost the only way in which melt- er can penetrate into the soil. The total nber of such funnels can be determined from distribution curve for freezing depth relative rea, and this in turn depends on the snow- th distribution curve.

The amount of water penetrating into the soil through thawed funnels which had existed before snow melting is insignificant. These funnels are rare and found only in deep depressions or under snowdrifts. Such funnels are almost nonexistent in winters when the snow falls on frozen soil. No such thawed areas were found in 1959 in about 500 probings of the peat deposit at various points of the drained bog, while in 1958 thawed funnels were found especially in the area adjoining the forest.

The penetration of water through thawed funnels in depressions at the soil surface influences the formation of the microrelief of drained bogs and the development of water "veins" within the peat deposit. This was observed by us during 2 springs in a virgin area of a newly drained bog. Meltwater, penetrating the soil under pressure, removed soil particles, compacted the peat bed, and formed filtration passages, or water "veins," in the soil. The soil surface near the funnels subsided. A similar "vein" also formed in the cultivated area, where the water flowed in a concentrated stream over the surface of the bog (because of the absence of an upland channel), filtered downward, and cropped out at the bank of the main channel in the form of a "vein."

In addition, infiltration through the frozen soil occurs in spring. Observations on the water intake made in holes 5-10 cm deep and 650-1000 cm² in area, cut in the frozen soil, and in natural puddles showed that the intake of water varies greatly, even at adjacent points. In 1959 the water intake in a well-drained autumn-plowed field under winter crops was analyzed by the experimental formula of Kostyakov $K = \frac{K_0}{t^{\alpha}}$, where K is the water intake coefficient in time t, K_0 is the same in the initial moment, and α is a coefficient (5). For frozen ground the mean value of α was 0.30, with K_0 averaging 0.0038 cm/sec. The intake rate in holes in the grass area averaged 0.00036 cm/sec, and that in natural puddles, 0.000039 cm/sec. The difference in the coefficients is attributable to the fact that the upper soil layer, most saturated with water, was removed when cutting the holes. The water intake was insignificant with shallow drainage. In 1960 the water intake was more varied. Only a few observation points fell near the foregoing curve, while in the majority of cases the intake was almost constant throughout the entire period of observation, the intake coefficient averaging 0.0002 cm/sec under winter crops, and 0.0003 cm/sec under the grass. An increase of the uptake coefficient with time was observed in individual cases (4-5 hours after the beginning of the experiment).

Thus, losses of snow water by infiltration into the peat deposit depend primarily on the state of the soil surface, and in a small degree on the depth of ground water. Observations show that surface runoff occurs both in a well-drained peat deposit, and when the ground-water level is high.

Conclusions

1. The ground-water level affects the freezing depth of peat soils. A considerable decrease in freezing depth occurs when ground water is less than 1.0 m below the surface. Well-drained bogs freeze the same way as moderately-drained bogs.

2. There is a clear relationship between the freezing depth and snow cover depth during the period of formation of maximum snow storage.

3. The water contents in the upper 30 cm of frozen soil increase by an average of 63.1 mm in winter as a result of moisture movement from the lower lying horizons. There is no relationship between the increase in moisture and ground-water depth.

4. When ground water is located below the frozen layer, the intense thawing of peat is determined exclusively by air temperature, which has a different effect on each microrelief feature (furrow, ridge, and flat surface).

5. The freezing of soil in shallow depressions of the microrelief (furrows) promotes the formation of thawed funnels in them, which increase the losses of snow water by infiltration and decrease surface runoff.

6. Surface runoff is insignificant on well-drained peat deposits.

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ARACTERIZATION OF THE AGRICULTURAL CHEMICAL OPERTIES OF MAJOR PEAT SOIL GROUPS OF KARELIA

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ne of the most characteristic features of Carelian climate is the deficiency of heat ng the growing period. This is due to the raphic location of the Republic, the prev- ce of maritime Arctic air masses over it ng this period, and the presence of a large ber of water bodies.

he comparatively low air temperature and igh amount of precipitation during the n period (70%-75% of the annual total) re- in high relative humidity (70%-89%), low oration, and a high moisture coefficient. e and the specific hydrogeological condi- of the region (high ground-water levels, water permeability of soils, etc.) are rincipal causes of periodic and constant ssive moisture, and of widespread bog and r-logged soils. Upland bogs occupy 37.5%, of the transitional type, 31.4%, and low- bogs, 31.1% (9) of the total peat-bog area.

Upland-Bog Group

reas of peat soils of the upland-bog group ound in Karelia mostly in depressions on rsheds, at the foot of gentle slopes, in en- ed basins, in lake basins, in deltas, and at the edges of bogs of the lowland and sitional types with a peripheral-oligotrophic of development (4).

ne of the characteristics of the majority of soils of the Karelia upland group is that are of a mixed nature. The majority of developed as a result of the evolution of nd and transitional bogs. In their botani- omposition, the upper horizons of these consist primarily of cottongrass-sphag- pine-cottongrass-sphagnum, and Scheu- ria-sphagnum varieties of peat (1). The ee of peat decomposition is usually low 15%-20%).

Soils of the Upland Group

ne results of our investigations, made at Carelian Branch, Academy of Sciences, (Table 1),[1] as well as data available in the literature and in archives (6, 7, 14, 15), show that soils of the upland group are characterized by a low bulk density (0.06-0.09), and a high water capacity, reaching 900%-1500% (based on weight of absolutely dry soil). They all have a low ash content. Silica and sesquioxides predominate in the composition of the ash residue. Total calcium and magnesium oxides are below 0.5%, as a rule.

In comparing average data on the sum of CaO + MgO with the pH and the degree of base saturation of the soil, one may note that the 0.5% calcium and magnesium content corresponds to a pH of 3-3.6, and a degree of base saturation of the soil of not more than 25%.

As a whole, the pH and ash content of peat in the upper horizons of bog soils of the Karelia upland group are somewhat higher than those found in the literature for peat soils of a similar group in the more southern taiga (10, 11, 12, 13). An explanation for this may be found in the enhanced role of runoff in the water balance of peat beds as a result of dissected relief.

The total content of phosphorus varies from 0.07%-0.12%, or 108-288 kg/ha. The potassium content of these soils varies from 0.02%-0.08%, or 48-216 kg/ha.

The total nitrogen content varies from 0.76%-2%, or 1.82-4.8 metric tons/ha.

The content of mineral (ammonium) and easily-hydrolyzed nitrogen in these soils is comparatively higher than in well-decayed peat soils of the lowland group. However, even in these soils the total of these forms of nitrogen usually does not exceed 2%-4% of its total content. Unfavorable physicochemical properties and the deficiency in ash elements are the main causes of the weak biological activity of peat soils of this group.

At the present time bog soils of the upland group may and must be used primarily for the preparation of litter peat in the agriculture of the Republic.

Peat Soils

Transitional Group

The majority of peat soils of the Karelia transitional group developed as a result of the evolution of soils of the lowland group because of the deterioration of conditions of mineral nutrition. According to a number of indices, characterizing the degree of impoverishment, soils of the transitional group may be divided into three sub-groups: early, medium, and late stages of improverishment. The principal morphological index of the degree of impoverishment is the amount of sphagnum present: the amount of sphagnum is usually small in the early stages of impoverishment, while it is very pronounced in the late stages.

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[1] ta given in Table 1 were obtained from the an- al treatment of data on the agricultural-chemi- roperties of key areas.

Dry valleys with poor sandy and sandy loam soils also become water-logged under the conditions of the Republic. The development of such bogs usually begins immediately with the concentration of vegetation of the mesotrophic type.

According to the data of Boch (1), the thickness of peat in such bogs is small (up to 1 m), while soils of the transitional group, formed as a result of the evolution of lowland bogs, are underlain by moderately thick and thick peat. The impoverishment of and the amount of sphagnum in soils, formed as a result of the water-logging of dry valleys poor in bases, are usually great.

The replacement of more demanding by less demanding plant groups and types of peat is accompanied by a change in the physicochemical properties and fertility of soil horizons. Table 1 gives data on the physicochemical properties, ash content, and chemical composition of two extreme types of soil of the transitional group. These data show that the indices of soils in a later stage of impoverishment are close to those of soils of the upland group, even though they consist of peats of the mesotrophic type; the sum of alkaline earth-bases varies from 0.3%-0.7%, or 0.72-1.68 metric tons/ha, in a soil layer 30 cm thick. This results in the increased acidity and in a low degree of base saturation of the soil. Indices of the content of ash elements and nitrogen are also close.

During the initial stage of impoverishment, when the amount of sphagnum is either small or sphagnum is absent, the agricultural chemical properties of the upper soil horizons are usually similar to those of peat soils of the lowland group with the low ash content (Table 1 — soil of alluvial plains).

Soils of the transitional group may be used both for the preparation of peat litter and as agricultural lands.

Lowland Group

Peats of the lowland group form under conditions of more favorable mineral nutrition and under various moisture conditions. This and the complexity of the relief, the diversity of underlying and surrounding geological deposits and soils in the catchment area, determine the variety of vegetation and soil under Karelian conditions.

Peat bogs which belong to the lowland type by their present vegetation and the nature of the upper horizons are found primarily in the tectonic faults in the bedrock of river flood pl rich in bases. Spring bogs are also in a lowla stage. The large bogs of the lowland type als formed in areas with a lacustrine-accumulativ relief, such as the Olonetz valley, the Shuya and Ladva lowlands, and other places. Howev a large part of them, devoid of supplemental alluvial or deluvial water and mineral nutritic is already in a stage of mesooligotrophic or mesotrophic development.

According to available data, peat soils con sisting of peats of the eutrophic type may be divided into a number of types according to th genetic characteristics and their agricultural chemical properties. These types are listed and described below.

Alluvial Plains

Soils of this type occur in slightly dissecte large massifs. They occupy a large part of th area covered by peat soils of the lowland grou As may be seen from the data given in Table soils of this type of bog, developed in lacustri alluvial plains, are characterized by a compa tively low pH (<5) and a low base saturation. They usually have a low ash content. A comparatively higher ash content (4%-6%) is usually found only in areas adjoining the hilly edges of dry valleys. The total calcium and magnesium rarely exceeds 1%, which is 2.4-3.3 metric tons/ha when reduced to the upper 30 cm layer. Thus, the majority of these soi have a low degree of base saturation.

The main mass of the ash residue consists silica and sesquioxides. These soils are not provided with phosphorus and potassium.

Unfavorable physiochemical conditions det mine the weak biological activity of the soil, which is confirmed by the low degree of decomposition of peat and the low availability of ash elements and, especially, of nitrogen, th total content of which is rather high (Table 1).

Thus, virgin peat soils of the lowland grou developed in alluvial plains, are poor in mine al nutrients, are comparatively acid, and wou require the application of fertilizers and limi when being reclaimed. However, in site eval tion, their site quality will be high because of their proximity to sovkhoz farms and the sligh dissection of the terrain.

Basins and Runoff Gullies

These soils occupy tectonic faults rich in b in parent material and are widespread in the former Trans-Onega and Kondopoga districts. They are locally found in other regions of the Republic.

The absolute ash content in the peat of thes soils varies greatly and consists primarily of sesquioxides and alkaline earth bases (CaO + MgO), so that the soil is more base saturated than the foregoing type of soils in alluvial plains. These soils are deficient in phosphor and potassium. Even though the total nitroge content is high in the upper 30 cm, reaching 1.75%-2.74%, or 10-15 metric tons, its mine

Table 1

Summary data on agricultural-chemical indices of the major types and groups of peat soils in the Karelian ASSR[a]

Group	Subgroup	Saline pH	Degree of base saturation, %	Mobile aluminum content, meq	Ash content	SiO_2	Fe_2O_3	Total	CaO+MgO	K_2O		P_2O_5		Nitrogen		
														Total		Easily hydrolyzed in % of total
					%				metric tons/ha	%	kg/ha	%	kg/ha	%	Metric tons/ha	
Upland peat	—	3—3,6	7,5—21,0	3,6—9,0	1,8—4,8	0,6—3,0	0,3—0,8	0,2—0,44	0,48—1,06	0,02—0,09	48—216	0,07—0,12	168—288	0,78—1,9	1,82—4,8	3—4
Low-land	Alluvial valleys	4,0—4,8	30—45	1,5—5,0	4—16	1,5—8,5	0,4—5,0	0,9—1,3	2,7—3,9	0,02—0,08	60—240	0,08—0,34	240—1020	1,8—2,8	5,4—8,4	2,2—3,2
	Runoff gulches	5,1—5,5	54—65	None	5,5—15,6	0,5—4,0	1,5—3,8	2,1—2,9	6,9—9,5	0,04—0,09	132—297	0,09—0,15	297—495	1,75—2,50	5,8—8,25	2—3,5
	Fed by ground water	4,4—5,6	52—81	0—1,5	6—47	0,7—3,6	1,5—38,0	1,0—6,5	3,3—21,5	0,02—0,14	66—462	0,1—1,75	330—5,75	1—3,8	3,3—12,54	1,5—2,7
	Flood-plain (alluvial-peat-bog)	5,1—5,7	40—82	None	13—56	1,4—40,0	0,8—5,5	1,0—5,5	12,69—20,62	0,2—1,1	2538—4125	0,1—0,5	1269—1875	1—3,0	11,25—12,7	2—4
Trans-itional	Early stages of impoverishment	3,8—4,5	30—40	2—4	4—7,8	1,96—3,2	0,5—2,0	0,5—0,9	1,2—2,16	0,04—0,07	96—168	0,1—0,2	240—480	1,2—3,1	2,88—7,44	1—3,5
	Late stages of impoverishment	3,3—4,0	20—30	4—7	3—5,0	1,92—3,0	1,0	0,3—0,7	0,72—1,68	0,03—0,06	72—148	0,1—0,15	240—360	1,2—1,9	2,88—4,56	3—4

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[a] The soils were analyzed by: L. Ya. Shifrina, V. A. Doil'nitsyna and N. D. Mal'kova.

Note: Calculations in tons and kg/ha were made for the upper 30-cm layer of soil.

Note: Comma represents decimal point.

and easily hydrolyzed portions are insufficient, which points to the weak biological activity of these soils. A large part of the bogs in this group was given priority in reclamation.

Fed by Ground Water

The water and mineral nutrition of such bogs is achieved primarily through variously mineralized ground water and ground water under pressure.

These soils are found everywhere. Their chemical and agricultural chemical properties are determined by the composition of the water which feeds a given area, the degree of mineralization, and the composition which are determined by the nature of the water-bearing horizons. As a whole, this type is characterized by a weakly acid, or nearly neutral reaction, and a moderate and high degree of base saturation. Nutrition by ground water has resulted in a low content of silica in the ash composition of the peat of these soils. Iron and calcium and magnesium oxide form the main portion of the ash residue.

Soils of spring bogs have the highest fertility potential. While belonging to the type with a normal ash content, these soils often have a high and enhanced ash content in the upper 10-20 cm layer as a result of the accumulation in it of iron oxide compounds. Such iron-containing, remineralized soils most often contain a high amount of phosphorus in the form of vivianite. Even though the content of total phosphorus (up to 1%-2%) and soluble phosphorus (up to 1%-2%) and soluble phosphorus is high in diluted solutions of mineral acids, it is only slightly available to agricultural plants.

The experiments made by us with the peat-humic iron-containing soil of the experiment station of the Karelian Republic, containing vivianite, confirmed that phosphates are not sufficiently available in soils rich in iron. The application of phosphate fertilizers to perennial herbs (clover and timothy) increased their yield by 60% as compared to the control without fertilizer. (2). Liming in small amounts (1-1.5 metric tons/ha) in a production experiment in the Zaytsev sovkhoz, increased the yield, apparently because of the increased availability of soil phosphates, since by all indications this soil did not need liming.

Peat soils fed by ground water are provided with very little potassium. The lowest amount of potassium is found in iron-containing soils.

The total content of nitrogen in metric tons in the upper 30 cm layer is high. There is a deficiency in its mineral forms. Investigations conducted by us on the dynamics of the mineral forms of nitrogen under field conditions showed that the process of mineralization of organic forms of nitrogen in these soils proceeds primarily to the stage of ammonification (3). Thus, even though peat soils fed by ground water are genetically homogeneous, they may vary greatly in their agricultural-chemical properties and require differential methods of increasing their effective fertility.

Alluvial-Peat Soils

Because of the nature of the drainage netwo of Karelia, river flood plains are weakly developed. Because of this, alluvial-peat soils occupy a small place in the total peat area of the Republic. However, in spite of the fact that they occupy a small area, these soils deserve attention and must be utilized as sour for forage production because of their high fer tility potential.

A considerable part of alluvial soils investi gated by us does not get flooded at the present time, as if representing young first flood-plai terraces (flood plain of the Vodla River, Lemishuo River, etc.). Part of them belong to temporarily flooded flood plains (that of the Ya gozerka and Pigmozerka Rivers). This makes it possible to improve and use them for agricu ture and must be considered in the site quality evaluation of bog soils.

Data of agronomical studies (Table 1) show that alluvial-peat soils are characterized by a enhanced and high ash content (13%-56%). Con sequently, the relationship between the minera and organic portions of the soils is more favor able so that the physical properties of these soils are more favorable and their biochemica activity is comparatively higher. The foregoing is confirmed by the high degree of peat decomposition and the comparatively high content of easily hydrolized nitrogen. Soils of this type are considerably richer in phosphoru and potassium than are other peat soils, and will either not need phosphorus and potassium fertilizers when reclaimed, or need them in small amounts.

Biological Properties of Peat Soils

Data found in the literature and in archives on the microflora of virgin peat soils of the Karelian ASSR indicate that they contain a very moderate amount of microorganisms, especially soils of the upland group. Nitrifyer and aerobic nitrogen-fixing bacteria are nonexistent in almost all virgin soils.

In order to be able to compare the differences in the quantitative content of the leading physiological groups of microorganisms in the virgin peat soils of the lowland group in Karelia and in Belorussia, Table 2 gives their comparative amounts, as taken from the work of Golub for Belorussia (5), and Katsnel'son for Karelia (8).

As may be seen from Table 2, the total amount of ammonifyer microorganisms in the upper layer of the Belorussian soil in July was 6-20 times greater than in the Karelian soil of the same group.

In comparing data on the quantitative composition of butyric bacteria taking an active part in the decomposition of cellulose (especia ly in virgin soils), one may see that there are 16.6-36.9 times less such bacteria in Karelian soils. The difference in the content of a very important group of microorganisms-actinomy — is not less pronounced. The same is found

Table 2

Content of leading physiological groups of microorganisms (in July) in millions per 1 g of dry soil

Place soil samples taken	Ammonifiers	Butyric acid	Dentrifyers	Actinomyces	Aerobic cellulose-decomposers	Spore-formers
Karelian ASSR	0,4	0,01—0,1	0,1	0,016	0,001	0,046
Belorussian SSR	2,209—8,004	0,166—3,686	0,136—0,167	0,211—1,305	—	0,943

lote: Comma represents decimal point.

spore-forming bacteria.

The main reasons for the weak development
the major groups of microorganisms and the
biological activity of peat soils in the Re-
blic are less favorable nutritional conditions,
se deficiency, and also the heat deficiency.
e foregoing explains the low degree of decom-
sition of peat and the low mineralization of
rogen in most of the peat soils, even those of
lowland group.

Conclusions

1. Because of their wide distribution and
nparatively high fertility potential as com-
ed to the slightly humic, bouldery podzolic
ls of Karelia, peat soils are the main basis
the expansion of plowed and meadow land.

2. Priority for agricultural reclamation is
en to soils developed in runoff gulches
ated in tectonic faults in bedrock rich in bases.
ing bogs and alluvial-peat soils are charac-
ized by the most favorable agricultural
mical properties and by natural fertility. At
same time, other soil types of the lowland
up must be reclaimed in a number of cases
agricultural-economic reasons.

3. The main problem in the reclamation of
elian bog soils is the mobilization of prac-
lly inexhaustible reserves of nitrogen, which
nains available for crop plants after reclama-
n.

4. Low biological activity is characteristic
northern peat soils. Methods of drainage and
lamation must be directed toward overcoming
property of peat soils, and increasing their
chemical activity and the availability of
rogen and ash elements.

5. The spatial heterogeneity of soils, even
hin individual areas, requires detailed soil
veys and differential reclamation methods.

6. Data from the literature (15, 16) and from
experiments indicate that the fertility of
elian peat soils can be increased by liming,
ing clays, applying mineral and biologically
ive forms of fertilizers, applying or turning
r of standing crops, and the use of proper
p rotation and other measures insuring the
rease of the biochemical activity and fertility
Karelian peat soils.

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EATHERING OF CALCAREOUS-ALKALINE GRANITES AND RANODIORITES IN THE FOREST ZONE OF THE IVORY COAST, ND THE SOILS DERIVED FROM THEM BY N.LENEUF

V. LOBOVA

This work of N. Leneuf is of interest to a e circle of soil scientists. The author made iorough analysis of the processes of weather- and presented a general picture of natural soil characteristics in tropical forests.

The Ivory Coast is located in West Africa ween 4°30' and 10°30' N latitude and 2°30'-)' W longitude, and borders on Ghana in the t, on Liberia and Guinea in the west, and on an and Upper Volta in the north.

The author investigated the southern part of country, which is almost entirely within the ion of the tropical rain-forest. The coastal of the country is occupied by gallery-type mpy forests with a herbaceous floor and t beds. There are two main types of forests plateaus and in plains: a) "Yarassa" forests he most humid equatorial zones (with pre- tation of more than 1700 mm) and b) "Celtis" ests, which are dense and semi-deciduous, reas with lesser precipitation (from 1500- 0 mm).

About two thirds of the forests in the Ivory st are "Celtis" forests. They are character- c of a uniform tropical climate without a long period and grow on clayey ferralitic soils. nid forests growing on clayey soils are ignated by Manzheno as pelohygrophilic, and se growing on sandy soils, as psammohygro- ic.

Areas covered by forests occupy a large part he country. Thin forests and savanna wood- l appear north of 6° N latitude and form a ding, V-shaped boundary line with rain- est areas. Savannas, which the author con- ers as relics, are found in the coastal part he country, (from the border of Ghana to sandra). Gulch and valley bogs are frequent- ound in this region. The major areas of the y coast are occupied by granitic outcrops, uding calcareous-alkaline granites and nodiorites. The coastal area consists of tiary sands and shales (in the east). Dolerite, vell as shale outcrops, are found in the west he country, forming a hilly relief.

As a result of his studies of zonal soils of the y Coast, the author came to the conclusion they are typical ferralitic soils in which the cess of ferralitization is weak since it does not lead to a sizeable accumulation of aluminum in any of the horizons.

The main section of the book is devoted to the weathering of granite under conditions of a tropical forest. The author made many chemical and mineralogical analyses of granite in various stages of weathering, and of friable products of weathering and soil formation found in situ.

The first phase of weathering, i.e., the phase without the participation of higher vegetation on the bare, lichen-covered granites, leads to the formation of loose, autochthonous deposits. After the disappearance of the structure of the primary rock, the following minerals were found in many profiles through the loose material (product of weathering): kaolinite groups, goethite, gibbsite, hydroxide gels, a large amount of residual quartz, muscovite, and a small amount of feldspar and heavy minerals. The molecular SiO_2: R_2O_3 ratio in the clay fraction ($<2\mu$ in diameter) was slightly higher than two, or close to it. The colloidal complex was unsaturated. According to contemporary soil classifications, such material is called lateritic, or ferralitic.

Having analyzed a large amount of material, Leneuf established the existence of two phases of granite and granodiorite weathering: the sericitization phase and the phase of colloid formation.

Sericitization (the appearance of potassium micas) intensifies with increasing temperature and moisture. A milky hue of a chalk-like nature (or having the aspect of pseudokaolinite) appears immediately in the first stages of granite weathering. Feldspars become friable and turn into white powder. The author called this stage "whitening." Alkali are released with a great intensity, which leads to the microcleaving of minerals in the rock, reaching the stage of micro-crystals. The considerable increase in the reaction surface associated with this leads to intense chemical disintegration. Successive analyses of the materials of the "whitening" stage showed a noticeable and progressive reduction of the amount of CaO, MgO, and Na_2O, while the K_2O content decreased slowly. This decrease is associated with the high stability of microcline and, especially, muscovite.

The author established by X-ray analysis that newly-formed minerals, such as phyllites and hydroxides, appear as the foregoing degradation takes place. The appearance of these "new formations" is divided by Leneuf in two phases: 1) kaolinitic and gibbsitic, and 2) kaolinitic and montmorillonitic.

The milk-white powder, forming on weathering minerals, was analyzed by the tri-acid extract method. The author emphasized that it is difficult to tell whether this extract affected the primary minerals, but it could still be established that the insoluble part decreases in the more weathered parts of the rock: thus its amount changed from 90% to 30%. The reduction of the amount of the insoluble fraction is characterized by the progressive accumulation of secondary minerals, which becomes continuous in mottled clay.

Secondary minerals were found in the colloidal fraction of the milk-white powder on weathered granites.

Metahalloysite, or fire clay, was found in the first stage, i.e., in the whitened rock; its crystallization was indistinct and its fabric was not fully oriented. Well-crystallized, typical kaolinite appeared in the end product of weathering—mottled clay. Gibbsite appeared in large quantities in the colloidal fraction only in the first stages of weathering.

As the medium acidified (when bases were removed from the parent material), kaolinization intensified at the expense of gibbsite and aluminum gels. The author established that the first and transitional stages of weathering, which are accompanied by the formation of poorly crystallized "fire-clay" kaolinite, are followed by a stage during which typical kaolinite forms because of the presence of gibbsite and sufficient amounts of silica, which progressively becomes released from the primary silicates.

Thus, typical kaolinite forms in mottled clay by the silification of gibbsite or aluminum gels in a moderately acid medium. The final and main product of weathering during ferralitic soil formation is kaolinite together with geothite, a small amount of gibbsite and residual minerals (quartz and muscovite).

The author especially notes the formation of iron hydroxides and gels, typical of lateritization, which turn to geothite with age. The montmorillonite stage is described in less detail in the book. It is mentioned that montmorillonite is found in the presence of sodium, calcium, and, especially, magnesium under conditions of poor drainage.

After examining the first stages of weathering, the author proceeds with the characterization of various groups of ferralitic soils, giving a description of the main classification subdivisions.

I. Plateau and slope soils, which develop on autochthonous materials. These are typical ferralitic soils. The profile of tropical ferralitic soil consists of the following horizons: 1) litter; 2) slightly humic, sandy-clayey; 3) leached sandy-clayey of a beige, ochre, or reddish color; 4) gravelly with quartz predominating; 5) a horizon where clay and concretions accumulate; and 6) a "mottled clay" horizon resting on weathering bedrock.

The upper sandy-clayey horizon which reache a depth of 10 cm contains 3%-4% of humus under an undisturbed tropical forest; under less rich vegetation it contains less than 1%. The C:N ratio varies from 7-14. Adsorbed cations are preserved in the soils because of the formation of complex compounds with the decomposed organic substances of the litter. The sum of adsorbed bases may be quite large in the upper horizon, but decreases sharply below 20-30 cm. The largest increase in total adsorbed bases occurs in the clay horizon. Their lowest amount (from 0.5-3 meq) is found in soils of the highest regions (SE and SW). The highest total amount of adsorbed bases, 9-12 meq, is found in soils of the central forest zone. The sum of adsorbe bases reaches 14 meq in soils on granodiorites. The predominating cation in the majority of soil is Ca^{++}. The Ca^{++}:Mg^{++} reaches < 1 on granodiorites. The potassium content varies from 0.04 0.6 meq. The pH of the foregoing soils varies from 4-6. The gravelly horizon is found at a depth of 30-120 cm in most soils on granites. This horizon, called "stone line", consists primarily of quartz, with an admixture of rounded iron concretions. The origin of this horizon, which follows the topography of the are is unexplained as yet. Assumptions are made about colluvial, lateral introduction, as well as about the influence of termites on the process of "stone line" formation (H. P. Nye).

The clay accumulation horizon appears from a depth of 1 or 1.5 m — this is the most clayey part of the profile. The formation of this horizon is explained by Leneuf as a result of lateral or vertical leaching. An intense formation of iron concretions takes place in this horizon. Th clay accumulation horizon is replaced by the "mottled clay" horizon, which is considered as a transition zone to the weathering parent material. The thickness of "mottled clay" varies from 2-11.15 m. The pH is usually 6.

An analysis of the clay fraction (<2 μ in diameter) showed the presence of kaolinite (60%-80%) and goethite (5%-15%). The gibbsite content was insignificant. The $SiO_2:Al_2O_3$ ratio in t clay fraction was somewhat less than two.

II. Soils of the lower portion of slopes on sandy colluvium. The humus litter of these soil is not continuous, partly decomposed, and varie in thickness from 1-2 cm; the slightly humic (0.1%-2% humus) sandy layer reaches a thicknes of 30-40 cm. The underlying horizon is of a beige color intersected by brownish streaks, the existence of which may be considered as the result of podzolization. However, Leneuf believes that the formation of these streaks is rather associated with the lateral migration of iron hydro xides, the more so because even the nature of the humus of the foregoing soils differs from the humus in podzolic soils (which is usually coarse

There is an accumulation of concretions unde the beige horizon, which form above the clay horizon with hydromorphic features. These soil are very sandy to a depth of 1-1.5 m; the <2 μ diameter fraction in the deeper horizons reache 10%-20%. The humus content varies from 0.8%-2%. The pH in the upper horizon is usually neutral, while deeper it points to an increase in acid reaction. The sum of exchangeable cations at the top, in humified soils layers, is 7 meq and drops to 0.9 meq in the deeper layers. However, the sum of bases usually increases in the clay layer. The deep horizons of soils developed on a granitic substrate are enriched with cations.

III. Valley soils on colluvium and alluvium. These soils develop on sandy allochthonous deposits, about 1 meter thick, which are underlain by a clayey autochthonous horizon on the surface of which rests a gravelly layer with iron concretions. The soil profiles consist of a black humus horizon and strongly leached light-colored horizons. The wettest soils are found at the boundary of the sandy and clayey layers. The soils are usually excessively wet, especially at the top.

Chemical analyses of these soils show that the pH varies from 3.8-6.4, and the sum of exchangeable bases reaches 44 meq, but is mostly less.

IV. Soils of granitic domes. Lichens colonize the bare surface of the granites, while grass establishes itself in more weathered areas. Primitive soils form under these conditions, consisting of a small amount of fine earth and humus. It was found that humus under the lichens is fulvoacid, while under the grass sod humic acids predominate in the composition of the organic substance; the C:N ratio is 12, the sum of adsorbed bases, 10 meq, and the pH, 5. The author comes to the conclusion that the acidity of these soils and their low saturation with bases makes them similar to the peat beds of temperate latitudes, but the intense decomposition of plant remains is characteristic of tropical weathering.

At the end of the chapter the author compares the soils studied by him with Ober's classification (1958).

In addition to the foregoing main positions taken by Leneuf, certain other conclusions made in the book are of interest. 1. The degree of ferralitization is better determined from the values of adsorption capacity, and from the preservation and amount of primary minerals than from the SiO_2:R_2O_3 ratio. This ratio points to ferralitization only in a general way. Thus, the lowest SiO_2:R_2O_3 ratio was found in soils of the most humid regions (more than 1700 mm precipitation), where typical ferralitic soils form; in less humid areas, with precipitation from 1300-1700 mm, weakly ferralitic or transitional (110-1500 mm precipitation) soils develop. 2. The mineralogical and chemical differences, established for the granites and granodiorites studied, affect the texture of the soils, their base and iron hydroxide content, and also the Ca:Mg, Ca:K, and Mg:K ratios. 3. Under the characterized ferralitic soil formation conditions, kaolinite is stable. 4. The chemical balance, determined relative to aluminum, showed that 1/2 and 2/3 of the bound silica and 1/3 of the quartz silicon dissolve and drain during the kaolinitic, gibbsite stage of weathering. 5. Minerals which are components of granite weather in the following order (determined by their stability): plagioclase > microcline > muscovite > quartz. 6. The boundary between savannas and mesophyllic forests is determined by general climatic factors; however, it noticeably changes under the influence of the substrate. Thus, forests colonize the more clayey ferralitic soils, while savannas develop on sandy, leached soils or on lateritic crusts. On the whole, the savanna holds on to physiologically drier soils, which, in spite of an excessively wet season, have a lower total moisture supply. Several concrete examples are given in the book on this subject. 7. According to observations of Manzheno and M'yezh, a renewal of forests takes place in the central part of the Ivory Coast, even on leached sandy soils and partly on lateritic soils, but the extremely unfavorable physical properties of certain soils limit the propagation of forests and lead to an alternation of forest and savanna in the boundary zone. 8. Determinations of the rate of weathering and of the absolute age of soils, made by Leneuf, showed that complete lateritization requires a great amount of time, even under humid equatorial conditions. Theoretical calculations showed that complete ferralitization requires from 20,000 to 77,000 years. The age of the ancient pleneplain in the Ivory Coast may be considered as Upper Tertiary. The presence of oolitic bauxites with gibbsite and boehmite at the surface is considered a result of the exposure of the iron-aluminum crust of the ancient pleneplain.

The brief description of the contents of the monograph of N. Leneuf presented here gives a general idea of the modern concept of the process of ferralitization (or lateritization according to the old terminology), both in the initial stages of weathering in the soils of granitic domes, during sericitization, during "whitening," and during the stages of fully developed ferralitic soil. Such mature (automorphous, in our sense) soils are plateau and slope soils.

The soils of the lower parts of slopes are hydromorphous ferralitic soils of the tropical belt.

In the descriptions of valley soils one can find a number of contradictions, which the author pointed out himself. The sum of exchangeable bases varies in these soils from 1-44 meq. The pH is also unstable, from 3.8-6.4. Carbonate concretions are found in a number of soils. Certain peculiarities, such as the increase in adsorbed bases and the appearance of concretions and montmorillonite in the composition of clay, are associated with the fact that the valleys cross savanna areas and not the zone of the tropical forest. The heterogeneity of chemical indices in valley soils is apparently related to the fact that these soils have the features of various zones: the humid forest, or the drier savannas. This is why we believe that the author of the book should have subdivided the group of valley soils into two subgroups, determined by zonal conditions.

The author has drawn a very clear and convincing picture when characterizing the various phases of weathering: sericitization, whitening, the formation of fire-clay, and kaolinitization.

The formation of montmorillonite during the weathering of rocks in the Ivory Coast is associated, according to the author, with the weakly acid, or neutral reaction of the medium, and with the presence of Mg and Na with a high $SiO_2:Al_2O_3$ ratio. These conditions, as may be seen from the description, do not correspond to those which occur during the various stages of ferralitization as described by Leneuf, and this is why we find it unconvincing when Leneuf points to the fact that the montmorillonitic stage exists during lateritic weathering (p. 176). However, the author notes right away that montmorillonite is found in valley soils and that it disappears rapidly when the reaction is acid. All this points to the fact, as we see it, that the formation of montmorillonite as that of a characteristic product of weathering must be considered within the framework of another zone—the zone of the dry tropics. From the clear picture of weathering given by Leneuf it follows that the formation of montmorillonite does not ente in the general chain of successive changes from rock to soil, but occurs only when considerable (this time zonal—Ye. L.) changes in the medium occur.

As a conclusion let us emphasize that the boo of Leneuf presents many analyses with descriptions of the methods used. An interesting part of the book is that containing short chapters devoted to the characteristics of the natural conditions of the profiles of the major soils. The bibliography contains 153 references. A shortcoming of the book is the absence of a soil map, which could have better substantiated the soil and genetic positions of the author.

CHRONICLE

CONFERENCE ON METHODS OF STUDYING HUMUS

M. M. KONONOVA, N. P. BEL'CHIKOVA, and I. V. ALEKSANDROVA

On June 3, 1960 a conference on methods of studying humus, organized by the Laboratory of Soil Biochemistry and Biology (Director, Prof. M. M. Kononova, Doctor of Sciences), was held n the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR. Participants included members of several scientific institutions in Moscow, Leningrad, and elsewhere (V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR; Forest Laboratory, Academy of Sciences, USSR; Moscow State University; Timiryazev Agricultural Academy; Leningrad Agricultural nstitute; and others).

M. M. Kononova presented a report entitled "New Methods of Studying Humus," which was ollowed by a discussion. Kononova noted that he use of new methods and techniques (electron microscopy, ultracentrifugation, infrared spectroscopy, different kinds of chromatography, etc.) are helpful in obtaining a deeper understanding of the nature and structure of humus substances. She illustrated her remarks by references to the literature and to her own research and that of her colleagues.

Kononova also emphasized the urgent need to streamline and perfect methods now employed by many soil scientists.

Paying tribute to the great contribution of I. V. Tyurin in developing convenient methods of studying humus, Kononova pointed out that recent years had witnessed the introduction of useful refinements in methods of determining organic carbon (V. I. Simakov, cf. Pochvovedeniye, 1957, No. 8; 1960, No. 4) and in Tyurin's procedures for determining the composition of humus. The latter include V. V. Ponomareva's suggestion concerning possible exclusion of alcohol-benzene extraction in the analysis of mineral soils (Pochvovedeniye, 1957, No. 8), L. V. Aleksandrova's recommendation for the use of an Na-pyrophosphate solution to extract humus substances from soil (Pochvovedeniye, 1960, No. 2), etc.

Kononova then described the results of work n methods performed in the Laboratory of Soil Biochemistry and Biology, Soil Institute, Academy of Sciences, USSR by N. A. Pankova, N. A. Titova, and T. A. Rudneva. The purpose of this work was to determine the following: 1) possibility of reproducing the results of determining humus composition obtained by Tyurin's method; 2) possibility of eliminating from the analysis routine certain operations (extraction by alcohol-benzene; use of 0.1 N NaOH to obtain humus substances following repeated alternating processing with acid and alkali); and 3) replacement of 0.1 N NaOH with a 0.1 M solution of Na-pyrophosphate to extract humus substances).

Comparative data in working with samples of the main USSR soil groups (strongly podzolic, sod-podzolic and gray forest soil, chernozem, and red earths) revealed that the results of determining humus composition obtained by Tyurin's method could be reproduced fairly easily. It was also shown that eliminating soil extraction by alcohol-benzene has scarcely any effect in the case of mineral soils, although this operation must be retained in working with horizons enriched with plant residues.

Exclusion of repeated alternating processing of soil with acid and alkali from the routine leaves the ratio of C humic acids to C fulvic acids unchanged. However, in so doing, the amount of residue of humus substances (humins) in studying chernozems grows markedly, but remains virtually the same in podzolic soils and red earths.

Kononova also discussed data obtained in the Laboratory of Soil Biochemistry and Biology on the substitution of 0.1 N Na-pyrophosphate for 0.1 N NaOH to extract humic acids from soil. The amount of humic acids extracted, it turned out, varied with the pH of the pyrophosphate solution and soil group. She believes that the problem requires additional study.

In conclusion, Kononova said that it was necessary not to limit oneself to quantitative indicators of humic acid content even in general analyses of humus composition, but to describe the nature of these acids as well. A convenient method for this purpose is to determine the optical density of solutions of Na humates equalized in content of carbon. This index reveals something of the degree of condensation of the humic acids, which is associated with several important properties (hydrophilic or hydrophobic nature, exchange capacity, etc.). It is also recommended that the proportion of humic acids to electrolytes be determined, which characterizes their degree of dispersion.

During the ensuing discussion the members of the conference described their own work. All noted the timeliness of the topic, for many scientific institutions and schools are studying humus substances and there is as yet insufficient agreement on research methods.

N. P. Bel'chikova (Soil Institute, Academy of Sciences, USSR), on the basis of extensive experimental material, declared that the analysis procedures of Tyurin might well be simplified. The fraction of humic and fulvic acids extracted by means of 0.1 N NaOH after decalcifying the soil is characteristic. On the other hand, the group of humic and fulvic acids extracted after repeated alternating processing with acid and alkali is quantitatively insignificant and not characteristic.

Bel'chikova then noted the possibility of eliminating alcohol-benzene extraction of soil from the routine except when the object under investigation contains a great deal of fresh and semi-decomposed plant residues (forest, peat soils).

Speaking of soil decalcification, Bel'chikova commented on the difficulties arising in determining carbon after using HCl. She stressed the possibility of decalcification with sulfuric acid alone when the soil does not contain carbonates or substantial amounts of exchangeable calcium.

T. A. Nikolayeva (V. V. Dokuchayev Soil Museum) discussed problems in reproducing results obtained by Tyurin's method, possible exclusion of alcohol-benzene extraction in studying mineral soils, and replacement of repeated alternating processing of soil with acid and alkali using the method of peptization with 0.02 N alkali and 6 hours of heating.

L. N. Aleksandrova (Leningrad Agricultural Institute) brought up several conditions impelling investigators to search for simpler methods that would at the same time reflect more clearly qualitative differences in the humus composition of various soils: 1) the length of time required for analysis in Tyurin's routine; 2) the difficulties involved in decalcifying carbonate soils; and 3) the striving to study not only free humus substances, but also their natural compounds with the mineral portion of the soil. She dwelt in particular on the advantages of using a Na-pyrophosphate solution instead of 0.1 N NaOH in extracting humus substances (Pochvovedeniye, 1960, No. 2).

Subscribing to the view that the humus-determination procedures could be simplified by eliminating several operations (alcohol-benzene extraction, repeated alternating processing of soil with acid and alkali), Aleksandrova called attention to the advantages of making an analysis from a single batch of soil with successive extraction of all fractions, including that of mobile humus substances. This method is possible in a laboratory possessing a centrifuge.

Aleksandrova concluded by stressing the need for more thorough study of the nature of humus substances by employing the new and convenient methods available to any laboratory.

D. F. Sokolov (Forest Laboratory, Academy of Sciences, USSR) discussed the need of greater accuracy and uniformity in designating fractions of humus substances (I-a, I, II, III). The lack of such unity complicates the task of comparing data.

I. V. Tyurin went into this problem in more detail at the end of his communication. On simplifying the procedures for mass analysis, he said that he favored exclusion of the fraction of humus substances obtained after repeated alternating processing with acid and alkali, and elimination of alcohol-benzene extraction in the case of mineral soils.

The conference adopted the following recommendation in the light of the views expressed.

The material now available to investigators on various soils makes it possible to simplify the method proposed by Tyurin for analysis of the composition of humus. In mass analysis it is possible to exclude extraction by an alcohol-benzene mixture and repeated alternating processing of soil with 0.1 N solution of H_2SO_4 and 0.1 N NaOH.

These steps can be eliminated from the analysis procedures because the amount of substances extracted thereby is slight and not indicative of the characteristic differences of the various soils. Exclusion of alcohol-benzene extraction in the case of mineral soils has no effect on the results of subsequent extractions of humus substances. Hydrolysis of soil by means of 1 N H_2SO_4 (with heating) and subsequent extraction of humus substances may also be eliminated.

Extraction with an alcohol-benzene mixture should be kept only for strongly podzolic soils and samples rich in plant residues (e.g., peat soils, sod horizons of mineral soils, forest litter).

For mass analysis the conference suggests the following abridgment of the routine to determine the group composition of humus, which is based on Tyurin's method.

1. Noncarbonate soils to be decalcified with a 0.1 N solution of H_2SO_4, carbonate soils — first with 0.1 N HCl, then with 0.1 N H_2SO_4. The amount of C organic substances is determined in the decalcinate. In the case of carbonate soils the amount of C extracted after decalcifying organic matter is determined from the difference in C content between the original and decalcified soil.[1]

2. Repeated processing of decalcified soil with a 0.1 N NaOH solution to extract the humic and fulvic acids loosely bound with the mineral portion of the soil.

3. Determination of C in the nonhydrolyzable

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[1] A variety of substances both of individual nature (carbohydrates, amino acids, compounds of aromatic nature, etc.) and some fulvic and humic acids turn into an acid solution. Classifying the substances of the decalcinate with the fulvic acids is correct only after analysis of the humus-illuvial horizons (authors).

esidue of organic matter.[2]

In a separate batch of original soil (without eliminary decalcification) a determination is ade of the content of so-called mobile (chiefly rown — free or presumably bound with mobile rms of R_2O_3) humic acids by one-time processg of soil with a 0.1 N NaOH solution and prepitation of humic acids in the solution. Subacting the resultant amount from the total mic acids reveals something of the gray (more omplex) humic acids bound with Ca (and Mg).

The conference considers it desirable not ly to determine the humus composition acording to the aforementioned routine but also describe the nature of the humic acids by dermining their optical density and resistance electrolytes (threshold of coagulation or prepitation). These determinations should be ade with the fraction of humic acids extracted om decalcified soil after repeated processing ith 0.1 N NaOH.

In determinations of optical density and coagulation threshold it is recommended that the solutions of Na humates be equalized in concentration of carbon and have a reaction close to neutral (pH 7.0-7.8), obtained by dissolving the dialyzed gel of humic acids in 0.02 N $NaHCO_3$.

The conference expressed the wish that further work be done to perfect methods for broad use. For example, in view of the possible need of analyzing the humus composition of a single batch of soil, the conference feels that it is desirable to carry on appropriate studies of methods in comparing the results obtained by this and by the generally accepted method used to extract the group of mobile humic acids in an individual soil sample.

The conference also went on record as favoring studies of methods using sodium pyrophosphate to extract humus substances, desiring more information on the following: 1) determination of the amount of humus substances that can be extracted from different soils by means of this solvent; 2) comparison of the results with the amount of humus substances extractable by means of 0.1 N NaOH; and 3) the forms of organomineral compounds extracted from soil by means of sodium pyrophosphate.

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[2] The nonhydrolyzable residues contain both humus bstances proper, solidly bound with the mineral poron of the soil, and plant residues not removed from e soil sample while being prepared for analysis uthors).

SEMINAR ON THE USE OF SOIL MATERIALS

V. N. KARAVAYEV

Some 60% of the soil in Artinsk rayon of Sverdlovsk Oblast' is made up of light gray sod-podzolic soil of low fertility. Erosion has developed and eroded soils constitute about 30% of the plowed land.

A large-scale soil map has been compiled for the entire area. Each kolkhoz has material on soil investigation: a soil map, cartograms of soil acidity, supply of nutrients, thickness of humus layer, and erodibility. A soil report is available along with the cartograms.

A seminar of kolkhoz agronomists and regional specialists was held in January, 1960, to discuss the use of these materials, with emphasis on those of commercial significance. Shevaldin, a kolkhoz with typical soil, served as an example. The problem was how to achieve maximum utilization of local fertilizers —manure, peat, tuff lime, peat ash, and imported mineral fertilizers.

Before the seminar the participants were informed of the significance and content of the aforementioned materials and the way they were employed to work out efficient farming techniques. They familiarized themselves with the data on Shevaldin—crop rotations, history of the fields, sowing areas, yield of manure, and amount of ash collected.

During the course of the seminar each participant calculated the area of the different soils on the crop rotation fields. They took into account the biological characteristics of the crops cultivated, cartograms of nutrients, fertility, nitrogen, phosphorus, and potassium fertilizer requirements.

The seminar concluded by recommending a reduction in the amount of lime and potassium and nitrogen fertilizers. It also suggested measures to control erosion.

N AMERICAN SOIL SCIENTIST'S IMPRESSIONS OF THE USSR

F. YAKUBOV

Dr. Charles Kellogg, assistant director of
e soil science section of the U. S. Soil Con-
ervation Service, has visited the Soviet Union
everal times, most recently in the summer of
)58 as head of the third American agricultural
elegation. While in the USSR Dr. Kellogg and
e other delegates visited many scientific in-
itutions in Moscow and other cities in the
ussian Federation, Ukraine, Belorussia,
azakhstan, and Uzbekistan. They also visited
perimental stations, and kokhozes and sov-
ozes in these republics.

Dr. Kellogg displayed considerable interest
soil science problems and in implementation
new knowledge by our agriculture. He set
rth his impressions in an article published in
il Conservation.[1] We propose in this note to
al only with those portions of his article
ich are of most concern to Soviet soil scien-
sts.

First of all, Dr. Kellogg points out that the
ze of farms in the USSR is very large as com-
red with those in America. As a result of
mbining kolkhozes we now have almost 90,000
lkhozes and sovkhozes. The USSR, he says,
ill has large areas of good land which could be
veloped by ordinary clearing methods and
owing, as well as by reclamation or irrigation,
ovided that drainage and prevention of saliniza-
on measures are instituted. He mentions the
eat progress made in mechanizing and
ectrifying agriculture, particularly after
achines from the Machine and Tractor Stations
ere turned over to the farms. "We saw,"
llogg writes, "excellent machines, including
ose for precise application of fertilizers under
variety of crops, especially grains and cotton.
ere are good machines for digging ditches
d performing other work, although some of
em are experimental models still awaiting
ass production." Dr. Kellogg also mentions
e substantial expansion of production and use
various fertilizers, notably phosphorus and
rogen, potassium fertilizers in many places
d trace fertilizers. Skill in the use and ap-
cation of fertilizers is growing, he goes on
say, but much will have to be done before the level of Danish, Belgian, British, and American farms, is reached. A serious problem, he adds, is the control of weeds, which raises costs as a result of excessive tillage and use of manual labor. Frequent tillage, moreover, tends to break down the soil structure. Therefore, to increase the effectiveness of controlling weeds, herbicides will have to be more widely used, particularly on grain fields, including rice.

Planning based on soil maps is generally good, Dr. Kellog writes. However, he observes that these maps, as compared with American maps, are defective regarding cartography and classification details. Owing to widespread knowledge among agricultural workers of soil classification and well-organized control, he adds, we saw comparatively few cases where unsuitable land was brought under cultivation. It is our impression that care is taken not to plow the soil in newly developed lands exposed to erosion or deflation. There are also very few cases of excessive destruction of vegetation on these soils by grazing cattle. Nevertheless, some other aspects of agricultural planning are not so well worked out. For example, there is substantial discrepancy between the plans and actual placement of crops on the fields. Water erosion, according to Dr. Kellogg, is, in general, a less serious problem in the Soviet Union than in the United States. This is due partly to the fact that most of the arable land is level or slightly undulant, and partly to the natural properties of the soils, and the very little amount of precipitation in the form of heavy rains. However, in many places streams of water every year wash away soil from the plains with ensuing large-scale gully formation. This is particularly noticeable along the lower Volga and Don Rivers, in the Urals.

It is noted that the Soviet Union employs such erosion-control measures as planting of trees and grass; but terracing and other construction works to combat gullies are not common, although they do exist. The author saw these methods used along railroads and near cities. Many good shelterbelts and windbreaks to protect crops from searing winds and soils from deflation were also evident. In general, deflation was not as pronounced as had been expected by the author from the literature. This year was in fact wet, and the soil showed no sighs of damage from deflation.

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[1] Kellogg, Ch. E. 1959. A visit to the Soviet Union.
l Conservation 24, 6.

This book states that most surveys of soil and water resources in the USSR are valuable, although generally not as good as was expected. Dr. Kellogg visited many research institutes with top personnel and facilities. Soil classification, he found, is not up to date, and is too theoretical. From 1870 to World War I the basic principles of classification were developed to a greater degree in the Soviet Union than anywhere else. The present system, with some minor changes and additions needed to compile more detailed soil maps, is largely work that the outstanding Professor, K. D. Glinka, developed during the 1920's. Many farms have soil maps on a scale of 1:10,000 and up to 1:25, 000. Present plans call for the compilation of maps for all the farms in most of the republics. Specialists in the universities and institutes are working very hard on the problem of soil classification. The agronomists, reclamation engineers, and other agricultural experts know the soil well, in which respect they are superior to their colleagues in the United States.

Reclamation work in the USSR, Dr. Kellogg notes, is done with good equipment although most of the swampy land, he believes, is overly drained. Here and there in irrigated regions drainage is inadequate, which fact may cause salinization. Some projects will not be successful without added drainage measures. Irrigation water is not always effectively utilized, as on some farms in the western part of the United States. Dr. Kellogg notes that "Our irrigators waste water, but it seems to us that Soviet irrigators waste even more. Although we saw many field experiments, none was well organized and carried out in accordance with modern standards. Experiments with fertilizers of rice are performed on 15 acre (6 ha) fields, and with grains frequently on 100-500 acres (40-200 ha). Such experiments naturally produce major errors. As a result the Soviet specialists themselves have doubts which have to be resolved by systematic replication of the field experiments and removal of chance."

"The Soviet Union is doing a good job in abstracting and translating foreign scientific literature. Many researchers read and speak English. They are clearly more familiar with our scientific literature than we are with theirs Many women are now being trained in agricultu schools. Some of them are fine agronomists a hold top jobs. A good many of them are also working in universities and research organizat The Soil Institute of the Academy of Sciences, U and its main division of soil geography and cartography include many women staff members w speak English very well. This institute carries great authority throughout the country in the field of soil science."

Kellogg adds that in the USSR as in the Unite States, forest belts are used to protect fields from dry, hot winds, while snow-retention measures are carried out in arid regions using special tractor-drawn equipment.

"Soviet kolkhozes and sovkhozes must incre production, especially of livestock, vegetables fruits, beets, and other commercial crops. Th can undoubtedly grow large enough grain crops for export. This will require the use of fertili constant improvements in mechanizing agriculture, perfection of transport, etc."

In general, agriculture in the Soviet Union, owing to the variety of systems employed, cannot be compared with agriculture in the United States or any other country with which Dr. Kellogg is familiar. In some places it excels that of America, in others it has shortcomings, and certain practices that are of doubtful value. Nevertheless, agricultural progress of the USS is truly impressive.

As mentioned previously, this review was n intended to cover all the points touched on in D Kellogg's article. We merely wish to observe here that some of them are treated with fair objectivity and competence, others in a one-sided and doubtful manner. This may have been due t the comparatively short time the delegation was able to spend in the Soviet Union, or perhaps to the space limitations of the article which prevented more thorough and rounded treatment of everything that the members of the American agricultural delegation were in a position to see.

TERNATIONAL SOIL BIOLOGY JOURNAL

S. GILYAROV

A new international journal dealing with the oblems of soil zoology called Pedobiologia l be published in 1960 in the German Demo- atic Republic.

The need of such a periodical is occasioned the steady growth in all countries of research soil fauna, the soil-forming activity of soil mals, etc., and by the mounting number of lications on problems in this branch of bio- y.

The purpose of the journal is to discuss in ail research findings on soil zoology obtained various countries as well as to present com- ehensive surveys of the work, problems, and ks to be accomplished in this field. The rnal will facilitate the exchange of theoretical l practical studies.

Although soil zoology will constitute the bulk materials to be published, some attention l be given to allied fields.

The journal will include the following types material: 1) methods and techniques of research; 2) ecology; 3) taxonomy (mostly on problems emerging from the results of ecological investigations); 4) theory, including biological statistics, etc.); 5) bibliography, abstracts, reviews; and 6) chronicle and general information.

Members of the editorial board are: Prof. J. Balogh, (Budapest); Prof. M. S. Gilyarov, (Moscow); Dr. C. Delamore-Deboutteville (Bantulle-sur-mer, France); Dr. R. Yosii (Kyoto); Prof. W. Kuhnelt (Vienna); Prof. O. Park (Evanston, Illinois); Dr. E. V. Törne (Jena); Dr. K. H. Forsslund, (Stockholm); and Dr. K. Strenzke (Wilhelmshaven, West Germany).

Articles will be submitted through one of the editors (through M. S. Gilyarov in the case of Russian articles — Moscow, B-71, Leninskiy Prospekt 37, Natsional'nyy Komitet Biologov Sovetskogo Soyuz [National Committee of Soviet Biologists]) or sent directly to the publishers (VEB, Deutscher Verlag der Wissenschaften, Niederwallstr. 39, Berlin, w-8, DDR) marked: "For Pedobiologia".

Pedobiologia will appear irregularly at first, then four times a year.

HOW NOT TO USE ANALYTIC DATA IN STUDING SOIL GENESIS

A. A. RODE

An article by Academician I. P. Gerasimov and O. A. Chichagova entitled "Two Soil Profiles of Rothamstead Experimental Farms (Rothamstead Experimental Station)" was published in Pochvovedeniye, 1960, No. 3. The authors used certain analytic data pertaining to two profiles on Rothamstead Experimental Station fields from which they drew conclusions concerning the genesis of these soils. A careful study of the communication shows that the methods employed by the authors to interpret the data are unsound and their conclusions arbitrary.

Let us consider the material on the second profile found on Broadbelt field. The data cited in the article relate to three layers: 0-20 cm, 20-30 cm, and 90-100 cm.

The authors use the ordinary method of comparing the composition of the different horizons. Finding that the clay content of the top two horizons (13.99 and 9.04%) is much lower than in the bottom (40.23%), they say: "The data of particle size analysis indicate that clay has clearly migrated (italics mine, A. R.) and is accumulating in the lower part of the soil." The authors further state that the top layers were eroded, the remainder being subjected to mechanical loosening. The "continuous action of filtering water" (we wonder just how much precipitation there is in Rothamstead to provide continuous filtration of water and whether this phenomenon is generally possible) caused a redistribution of clay particles in the soil profile. The authors give their views on the genesis of the soil, relying on the data cited. We shall not repeat these views here and ask those interested to refer to the article in question.

The authors made a serious error in interpreting the analytic data. Even a cursory glance at Table 7, which contains the particle-size data, shows that the bottom 90-100 cm layer, into which clay particles are supposed to have migrated, is clearly another deposit (or another layer of the same deposit) than layers 0-20 cm and 20-30 cm. This is suggested by the fact that the 90-100 cm layer contains 22% of the 1-0.25 mm diameter fractions, whereas the upper two layers contain 2.5% and 1.5% of this fraction. Particles 0.01-0.005 mm diameter (the original has 0.001-0.005 mm, evidently a typographical error) amount to 25% and 24% in the upper two layers and 7% in bottom layer.

The method of comparing the structure of different horizons widely used by scientists in studying soil genesis is based on a number of assumptions, the most important being that of original homogeneity of that layer of parent material from which the soil was formed. Admittedly we lack positive proof of the soundness of this assumption. At best we have some bits of negative evidence. The simplest is the similarity in content of coarse fractions in the various horizons which change comparatively little during the process of soil formation, or at any rate do so more slowly than the fine fractions. The identity of content of coarse fractions shows tha there is no justification for rejecting the assum tion of original homogeneity of parent material. However, the difference in the content of coarse fractions in the various layers is undoubtedly positive proof of the fact that the parent materi was originally heterogeneous and that it is impossible to use the comparative method to make deductions about the genesis of the soil.

This is precisely what we find in the communication of Academician I. P. Gerasimov and O. A. Chichagova, for within a single meter of soil there are at least two different deposits, and the difference in composition is primarily the result of the different geological origin of these deposits. It may well be that the 30-90 c layer contains still other layers, but there are no analytic data to confirm this.

The inadmissibility of comparing different layers known to be geologically heterogeneous weakens all the genetic conclusions of the authors.

Perhaps the brief communication was not wor all this attention. Yet such arbitrary interpretati of analytic data published on the pages of the influential Pochvovedeniye by such an authority as Academician I.P. Gerasimov might lead to imitation by other investigators, especially young men and women. It is quite tempting to use some facts arbitrarily and quietly ignore others. This purpo of my note is to prevent, if possible, repetition of the error committed by the authors of the article under review. It seems to me that the editors of the journal should be more critical of the articles that they accept for publication.[1]

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[1] The editors are in full agreement with A. A. Rode practical remarks. We also consider his stricture against our uncritical attitude toward the article in question wholly justified.

ASILIY ANDREYEVICH CHERNOV, 1901-1960

Soviet soil science and agronomy have suf-
red a severe loss. On August 12, Professor
siliy Andreyevich Chernov, Doctor of Geo-
gicomineralogical Sciences, died suddenly.
had been Director of the laboratory of soil
emistry of the V. V. Dokuchayev Soil Institute,
ademy of Sciences, USSR, and a Stalin Prize
ureate.

V. A. Chernov was born in 1901 to a peasant
mily living in Smolensk Oblast'. He served
the ranks of the Red Army from 1921 to 1923,
d in 1923 was admitted to the biological di-
sion of the Physics and Mathematical Faculty
Moscow State University from which he was
aduated as an agricultural chemist.

In 1929, Chernov began his scientific career
the Scientific Institute of Fertilizers, VSNKh
ow NIUIF), where he conducted his first in-
stigations on fertilization of potatoes and
ning of soils. Vasiliy Andreyevich trans-
rred to the All-Union Institute of Fertilizers,
inistry of Agriculture, USSR (now VIUA),
ere he carried on extensive research on the
ovement of anions and cations in soil. This
rk was a prerequisite for elaborating sound
ethods of applying mineral fertilizers.

April 19, 1935, V. A. Chernov began to work
the Soil Institute, Academy of Sciences,
SR, initially in the laboratory of soil physical
emistry, then (from 1948 on) as Director of
laboratory of soil chemistry. It was in this
stitute that he performed his classical ex-
riments on exchange bases and adsorption
mplexes. He was particularly interested in
il acidity. His monograph Priroda pochven-
y kislotnosti [Nature of Soil Acidity] sums up
brilliant original experiments. He was
arded the Stalin Science Prize for this work.

In recent years Chernov concentrated on
ace elements. Accurate methods of deter-
ning the most minute amounts of these ele-
ents and ascertaining their presence in the
rious soils of the USSR were worked out
der his direction.

Besides his activity in the Soil Institute,
ernov served as a consultant in the All-Union
search Institute of Building Ceramics begin-
g in 1951. There, he pioneered in studying
physico-chemical properties of clay using
eories of soil science. The following prob-
ns were investigated under his direction:

Effect of the colloid chemical properties of clay—degree of dispersion, amount of exchangeable cations, composition of adsorbed anions, amount of water bound with clay—effect of electrokinetic phenomena on the casting and filtration properties of clay suspensions and the physicomechanical properties of castings from them, effect of the interaction of clay suspensions and inorganic electrolytes and certain organic substances, casting properties of clays from new deposits.

The work done under Vasiliy Andreyevich's guidance is of great theoretical and practical value. For example, it made possible the industrial use of new and improved control methods for sanitary-construction objects whereby the operation of casting conveyors could be efficiently organized. Another contribution was a method of treating pure troshkovskiy clay, thus enabling the ceramic enterprises of Eastern Siberia to utilize local raw materials.

Through Chernov's death Soviet science has lost a worthy follower of K. K. Gedroyts' theoretical studies in the field of absorbing complexes and exchange reactions in soil. Chernov's work was always distinguished for its exceptional mastery of analysis and experimentation.

Chernov's investigations were closely bound up with timely problems in agriculture and industry—application of fertilizers, liming, improvement of soil fertility, utilization of mineral raw material.

Along with his research in the Soil Institute and All-Union Research of Building Ceramics Chernov did a great deal by way of training young scientific workers. He guided graduate students, instilling them with love for delicate, original experimentation, a many-sided approach to problems, deep and wholly objective analysis of experimental data.

The staff of the Soil Institute has lost in the person of Vasiliy Andreyevich Chernov not only an outstanding scientist, but also a splendid friend and active public figure.

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